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LIST OF LEADING ARTICLES.

The Wireless Situation.......... 359
The Maintenance of New Equipment.......... 359
Proposed Column Tests.......... 360
The Reinforced Concrete Reservoirs and Aqueduct of Mexico City (Illustrated).......... 362
The Phelan Building, San Francisco (Illustrated). 366
The Effect of Tunneling Operations on St. Paul's Cathedral, London (Illustrated).......... 369
Waterproofing Ballasted Bridge Floors at Schenectady, N. Y. (Illustrated).......... 371
The New Freight Depot of the Wisconsin Central Ry. at Minneapolis (Illustrated).......... 374
Test of a Small Suction Gas Producer Plant.......... 375
A Sewage Disposal Plant for a Large Hotel at Bedford, Pa. (Illustrated).......... 376
Construction of the Main Dam of the Croton Falls Reservoir (Illustrated).......... 377
The Storage of Anthracite Coal.......... 381
Tests of Boiler Settings by the Board of Education, Chicago, Ill. (Illustrated).......... 382
The Fire at the Dayton Motor Car Works (Illustrated).......... 384
Book Notes.......... 386
Resistance to Fire of Concrete Blocks.......... 386
The Capitol Subways at Washington.......... 386

The Wireless Situation.

Just now the control of wireless telegraphy is a subject of necessity uppermost in the official mind, and divers plans for its regulation are before our own Congress as well as international bodies. Truly the situation is a very curious one. Here is a new art already of large importance and with possibilities as yet unknown, but of a most sensational character. It is an art that knows no boundaries in space, natural or artificial. Commercially its importance is at present almost wholly maritime, since as a rule transmission overland even for very moderate distances has been a failure or at best a dubious success. Marconi is pegging quietly away at his trans-Atlantic service, meeting difficulties more or less serious but nevertheless building up an important service. The navies of the world are depending more and more on wireless messages and the Governments of the world are building up coastwise systems of immense scope. With it all syntonic methods have thus far made practically very little progress and messages entrusted to the ether wander where they will, so that, willy-nilly, every station within reach may receive them at any time from any direction. Whatever may be one's views as to government ownership or rigorous control, it must be admitted that if there is any such thing as a natural governmental monopoly, wireless telegraphy with its boundless possibilities of international interference is such a thing. Natural monopolies there certainly are, and a monopoly that implies a common use of the ether over a large part of the world surely looks like a case for national and international control of a very peculiar character.

Suppose, for instance, that France and Germany should come to a clash. With unrestrained wireless telegraphy in England and Switzerland, not held to any international responsibilities, the situation would be a very troublesome one. What nation could guarantee practical neutrality with wireless companies sending at will messages across belligerent territory. In our own country the danger of unrestrained wireless in case of war is only too obvious. The United States is at a disadvantage compared with every other civilized country in the matter of unrestrained publicity. Japan gave the world a lesson in the value of secrecy that it were well to heed. Could one of our fleets make a rendezvous at "a certain place" without half a dozen dispatch boats on its trail and publishing its whereabouts primarily to the people at home and incidentally to all the world? With unrestrained wireless, secrecy would be practically impossible. Of course, in case of war a censorship would be established, as it was in the Spanish war, but unless censorship of wireless meant practical cessation of commercial messages it would be of very little value, for while a cable has a definite terminus at which some degree of responsibility exists, wireless has nothing of the kind. The necessity of suddenly assuming government control in case of need is a very serious matter. It is far better to keep so effective a control all the time as to make it easy to make that control complete when necessary. This is virtually the purpose of some of the proposals now under consideration, and however drastic they may seem at first thought they deserve respectful consideration. Even if the United States is fortunate enough to enjoy a long period of peace, the necessary preservation of neutrality when other nations are at war should be a matter of the gravest concern. Had wireless existed practically during the Cuban difficulties prior to 1898 it would have been a perpetual source of worry.

The matter is really a very big one and will require the wisest and most far seeing of constructive statesmanship for its safe solution. One of the minor dangers that cannot be passed by in view of fortunately harmless recent occurrences, is the probability of fake messages for the purpose of affecting the stock market or for purposes even more sinister. Sent from nowhere in particular and received everywhere they would have a possibility of mischief almost unlimited. The game was tried even during our own Civil War, by methods which now would seem clumsy enough. A wireless message of defeat, driven home by wireless confirmatory details, would only with difficulty be disproved, particularly if the United States were at peace and its control loosened. The solution of difficulties like these can be had only through the international action that is now taking form, and the first necessity is sufficient power in the hands of each government to compel respect of international obligations. No such situation has before arisen in the world's history and in some wise it must be met. The first serious war within the ever-widening field of wireless action will bring the necessity home to everyone. Our country is wisely slow in entering upon governmental control of industries; its history and the temper of its people tend quite in the other direction; yet to-day the United States is of necessity assuming the obligations of a world power and cannot ever with honor put them aside or shirk them. Hence in this case, however unpleasant the necessity may seem to be, it is up to the United States to take effective action. This is no place to pass upon the details of the projects already made, for they need statesmanship rather than engineering discussion. The main thing technically is that the probable growth of the art should be looked out for and such action taken as may easily be modified if necessity demands. Meanwhile it is up to the engineers of the wireless systems to develop syntonic action up to the point where it will tend to simplify the necessary regulations against interference in time of peace.

The Maintenance of New Equipment.

The purchase and installation of new equipment for industrial service, its testing by the operating organization and acceptance by the executive authorities of the enterprise, mark the termination of the designer's responsibility unless the contractor guarantees a certain minimum repair cost for a stated period after regular service begins. It is an easy matter in a great many cases to lose sight of the question of early maintenance in the adjustment of new machinery to the actual conditions of commercial running. This is particularly true when the apparatus contract calls for no special low limit of repairs in a year or more. If the equipment is a standard type with no new features, it is liable to go into service without ceremony. If it is a new type, it frequently happens that the various operating troubles that tend to develop in the first few months of use quite obscure the cost of maintenance. Hence a company sometimes cannot tell with any accuracy after a year or two of service what the real maintenance of its later equipment is for definite conditions of operation. It is more important to secure this kind of information than is always appreciated, for it is helpful in guiding the company to new selections of equipment no less than in providing data for appropriations, estimates and anticipated operating costs.

In regard to the maintenance of standard types of equipment, it is seldom that even well-tried apparatus is subjected to duplicated service for both old and new equipment. In most lines of work the tendency is for the later equipment to be given harder and harder duty, and while the general type of apparatus may not change for some years, the capacity of individual machines seems to rise in a greater or less degree, according to the progress in the particular industry concerned. What is needed in a large number of industrial situations is more accurate knowledge of the conditions under which certain annual costs of repairs are developed. It is not enough to know that a given type of railway motor on a certain street car system cost in repairs so much for each motor in the first year of service. We must know what that service was in a complete statement before any intelligent deduction can be drawn as to the fitness of that type of motor for that company's lines. In like manner, the total cost of repairs on a motor direct connected to a rapidly reversing body ironer in a laundry may be an interesting figure, and suggestive in comparisons of the same service by a different size of motor or type of drive, but unless the essential facts of the service are given, at least in an average figure of the hours of use per day and the number of reversals in an hour, sound conclusions are pretty difficult to reach, as far as estimates of the cost of maintenance under varied conditions and the adaptability of a certain motor to a definite installation are concerned. Established types of machinery, then, are capable of furnishing valuable data as to the general problem of maintenance, once the opportunity is realized by the purchaser.

Little argument is needed to show the importance of keeping close track of the cost of maintenance in the case of new and hitherto untried machinery. The collection of this kind of information is often overlooked, at least until the apparatus wears out to a point where renewals attract attention on account of their frequency. Numerous troubles with a new piece of machinery do not necessarily mean that its repair bills are going to run high, for improper assembly and unskillful adjustment in new locations are often responsible for failures in service which really cost very little from the standpoint of repairs. But it should never be forgotten in any plant or system where the equipment is operated according to progressive practice, that the first few months of a machine's life are just as much a part of its working existence as the last weeks of its adjusted service. With a well-designed piece of machinery, the cost of repairs in the first year or two are bound to be less in general, than later, but it pays to keep a sharp watch of the early renewals and adjustments requiring moderate expenditures for materials, for here is often the clue to the maximum wearing parts and the less rugged features of the design. It may be the case that the early analysis of these apparently trifling costs of renewals and skilled alterations will show the operating man and the manufacturer of equipment where certain betterments can be made without the longer testimony of several years' service under less definitely studied conditions. During the first year or two the costs of maintenance of a given machine may not be one-quarter of the figure at the end of the first five years, but it is a help from the standpoints of evaluating depreciation, of estimating the proper average charge for repairs, and of selecting still more modern apparatus for later service requirements to note the tendencies of these running cost figures as the months go by. If the second year of service shows about the same repair charges as the first, it is worth looking into, and if the charges tend to increase at a fairly constant rate, it is no less desirable to try to estimate the probable duration of the regular increase and to set about cutting down the charges as soon as they reach the maximum consistent with good service.

It ought not to be a difficult matter to secure data on the repairs of individual machines handling a given service in a well-organized plant. With a clearly designed card system one man can keep track of the history of many hundreds of different machines. During the past two or three years, for example, the Boston Elevated Railway Co. has been keeping a close card catalogue record of all the defects developing in service by its cars, and the clerical work of this task has been handled very largely by one employee. The company owns about 3400 passenger cars, of which some 1500 are operated at one time in each season, but the analysis of these troubles from operating reports summed up on the cards has helped reduce the number of failures well over 40 per cent, speaking in the rough. There is no reason why similar good results should not attend the use of a simple but complete record system of new equipment repairs and general maintenance, if the service details are given with sufficient fulness, in any industrial plant where the cost of operation under new conditions is more or less of an uncertain quantity. The cost of repairs may not be lowered, but exact knowledge will take the place of estimates based on the service of unlike installations and the selection of future equipment will inevitably be more intelligent.

Proposed Column Tests.

At the meeting of the American Society of Civil Engineers held on March 4, a resolution was adopted suggesting to the Board of Directors the appointment of a special committee to investigate steel columns and struts and to report on their design, ultimate strength and working strength. This action was reported in the Current News Supplement of this journal on March 14. Whether the American Society of Civil Engineers, directly or indirectly, should undertake this investigation under conditions which might be developed later on, is a question about which much can be said on the ground of general policy. It is not the present purpose to comment upon the project as a matter of policy, however, but only to consider broadly what such an investigation should cover by whomsoever it may be undertaken. The resolution was prompted by the paper presented to the Society a short time ago by Mr. J. R. Worcester on "Safe Stresses in Steel Columns" which received editorial comment in this journal at that time.

There has been for a long time a feeling among engineers that the designers and builders of steel columns tread upon rather uncertain ground wholly in consequence of the paucity of tests of full-size compression members. Even were the older tests of wrought-iron columns directly available for present purposes, the comparatively small size of these columns would render the results ill-adapted to the requirements of present structural practice in large compression members with cross-sectional areas far beyond anything contemplated when the older tests were made. There is an apprehension among some experienced engineers that, while it seems entirely rational and safe to draw inferences respecting the ultimate carrying capacity of large columns from the tests of full-size but much smaller columns, there will be a substantial break in the line of proof as long as results of tests of columns of large areas of cross-section remain unknown. Only one such steel column test has ever been made, and that was the so-called model column, tested at Phoenixville, Pa., last November, in the course of the investigation made to ascertain the cause of the Quebec bridge failure. The area of cross-section of that column was 84 sq. in. and the results of the test were quite in accord with the general principles of column design as they are now recognized, but, unfortunately, while those results supplied precisely the information desired, the latticing of the columns was so designed as to develop the conditions of the anchor-arm chord members at the time of the collapse, rather than to develop the full strength of the compression member as a whole.

Among the lessons of the Quebec bridge failure there is none more forcible than that showing the need of just such full-size column tests as those covered by the resolution in question, and under whatever conditions such a series of tests may be undertaken one of the imperatively essential features of the investigation is the testing of steel columns of the largest practicable areas of cross-section. If there is no testing machine at present in existence to accomplish this purpose, steps should be taken to find means to construct such a machine. There is at the present time some talk of establishing a great testing laboratory under the auspices of some branch of the Federal government, a part of whose equipment should be a 2,500-ton testing machine. Such a laboratory would yield results of the greatest national value, to speak in a broad sense, for it would have sufficient capacity to settle by full-size tests many structural questions which now remain open and which must continue to remain open until some such experimental facilities become available.

In addition to this feature of the experimental study of the largest possible columns, there are many important questions of design which can be answered by series of tests of columns of more nearly ordinary dimensions. In fact, comparatively few tests of similarity, so to speak, between the largest possible columns and those of ordinary size would show whether it is safe, as it probably is, to reason regarding the main principles of design from ordinary compression members to those of much greater dimensions. That main or general principle being settled, it would then be necessary only to carry on the investigation with columns of usual size.

This part of the investigation would cover in the main two classes of results, viz., one to determine the correct elements of design of such details as lattice bars and their riveting, the proper limit of unsupported width of plate, now taken at thirty-five to forty times the thickness, the proper length of unsupported leg of angle in terms of its thickness, and other similar details; the other, the ultimate resistance of the column with its main parts held by properly designed details established under the preceding lines of investigation. The great difficulty with this whole question at present lies in the fact that engineers know neither how to design with certainty the spacing and other details of compression members nor the safe working resistance of the columns designed with proper deails. There are some reasons to suppose that the ultimate carrying capacity of the usual compression member is but little above the elastic limit of the member as a whole, but with the exceedingly meagre and unsatisfactory data now available, it is possible to determine neither the elastic limit of the column as a whole nor its ultimate carrying capacity under any design of details which the most experienced engineer can attain. Any series of investigations on full-size steel columns which will supply these data so much needed would be of inestimable value not only to the engineering profession, but to the country at large.

Notes and Comments.

ELECTRIC TRACTION ON CANALS, the subject of an interesting paper by Messrs. Stillwell and Putnum, reviewed in this journal last week, is destined to receive far more attention in the near future than it has in the past. While mechanical traction has been studied quite extensively on European canals, the necessity for any such investigation has not existed in this country until recently. The railways have always been able to carry all the freight, although at pretty high rates for some classes of it, until within a few years, but since the congestion of railway traffic that existed for eighteen months prior to last October, it has been recognized that the canals, now lying practically unused in most cases, have a future of much promise provided the cost of operating the boats can be reduced. Mechanical traction naturally suggests itself as a means of lowering these expenses, but when it is thoroughly examined it will generally be found to be less economical than the humble mule. The crux of the matter lies in the fact that the cost of traction is simply one item among a considerable number, all of which must be considered together. It would be ridiculous to put a heavy consolidation locomotive on a branch line to handle a few freight cars every day. In the same way it is ridiculous to install a mechanical traction plant on a canal for a few boats. The mule can beat it out in maintenance expenses. It is only as the volume of business on the canal becomes large and the delays in lockage are minimized that mechanical traction offers advantages. This does not mean, however, that mechanical traction does not have an encouraging future. As a matter of fact this journal is sufficiently convinced that canal transportation will grow in importance in this country to anticipate that before long at least a few canals will be equipped with the electric tractor.

CANAL IMPROVEMENTS which contemplate the use of electric or other mechanical traction have to be considered in the light of a condition which introduces some rather unusual complications. Most canals are governed by laws or franchises which require the canal tow-path to be a sort of public highway for the use of anybody desirous of hauling boats. For many years to come mules will be employed for hauling most boats. Their presence on the tow-paths introduces a condition which must control the technical details of mechanical traction. There are many of these paths which are so narrow that they could not possibly be utilized for mules and for traction locomotives at the same time. They are not wide enough for the purpose and the cost of widening them would be excessive. Moreover, it is something of a question whether the mule would retain his placid calm while passing a locomotive running along a track so close that the machine would graze his hide. It is this fact which has led The Engineering Record to the opinion that probably the form of traction which will ultimately prove successful will consist of some type of elevated rail between the tow-path and the canal on which a tractor will run. The amount of power actually required to haul boats is not very large, for repeated tests have shown that there is a limit to the speed with which boats can be hauled economically through a restricted waterway; in fact, Benjamin Franklin made some interesting observations on this subject and his notes concerning them were reprinted in this journal several years ago. It is because of this necessity of restricted speed and the small amount of power required that the light tractor seems to have technical as well as physical advantages over the heavy and larger locomotives.

BOTH BRIDGE AND TUNNEL HAPPENINGS of the first magnitude occurred last week at New York. The last opening in the Blackwell's Island bridge superstructure was closed and the last of the four tubes of the Pennsylvania R. R. under the East River was pierced, finishing the shield work. It was an interesting coincidence that such important events in both bridge building and tunnel driving occurred almost simultaneously, for it is well known that the engineers of the city are divided into two partizan bands, one of which sees next to nothing of good about tunnels while the other regards bridges as tremendously expensive means of communication, not to be compared with tunnels for low cost and general usefulness. Both the bridge and the tunnel have been so fully described in this journal that it is unnecessary to say more at this time concerning them. The rapid transit situation, however, has reached a stage when it is about time for the public to receive some consideration, even if this involves the temporary cessation of the continual wrangling over subways which seems to afford great pleasure to the Comptroller and the Borough President of Brooklyn. A fortnight or so ago there was a convention held in the city, under the patronage of various reform and charitable societies, for the purpose of discussing remedies for the squalor and immorality incident to existence in the congested district. Every intelligent man knows that the only remedy for conditions of living in lower Manhattan, not fit even for beasts, is to provide adequate means of rapid transit at low rates of fare. Moreover, a very large proportion of men and women in business in the city have to spend from half an hour to an hour daily jammed together in cars in a fashion that, if followed with animals, would produce instant action by the Society for the Prevention of Cruelty to Animals. During the last month the public demand for more subways has become so insistent that the authorities, or at least some of them, have shown signs of really trying to do something. When several hundred substantial business men, representing a very large proportion of the important manufacturing and commercial organizations of a great borough, attend a session of a public board, as they did recently, for the purpose of learning for themselves what is being done by that board to further rapid transit, it does not require profound intelligence to recognize that the time for horseplay for the galleries has passed and the time for action has come. So there has been a tremendous activity in searching for ways to raise municipal funds for such work, and finally a piecemeal plan has been suggested. It is proposed to build as much subway each year as the city can legally pay for. Whether this is a good plan or not depends upon two things, the time it will take to complete the work and the arrangements that can be made for operating the subway when built. If it will take ten years to build the Lexington Ave. line under such a plan, it is wholly inadequate; if it will take only five years, it has distinct merit. Nobody seems to know, however, just how long it will take, because if there is anybody who really knows what the city can spend on such work and still stay within the debt limit he keeps the information a dark secret. Outside of the heavier interest charges, there seems to be no reason why the construction by successive sections should be more expensive than the simultaneous construction of all the sections by various subcontractors. The various perplexities of all such municipal construction fall away, however, when private construction under adequate legal safeguards of the public interest is considered. The subways must be operated by private companies, so why not make a single, well-planned enterprise of each of the new routes so much desired, and turn the whole work over to private capital, as suggested by the Public Service Commission weeks ago?

SEWAGE DISPOSAL PLANTS in New York State will ultimately prove the source of valuable engineering information if the plans of the State Department of Health are carried out. There are 55 disposal plants in New York at the present time, of which 30 are for the treatment of municipal sewage and the remainder are for the sewage of institutions of various kinds. Among the municipal plants there are eight which employ sedimentation and contact beds, eight which employ simple sedimentation which may or may not involve septic action, six using sedimentation due to the addition of chemicals, five employing sedimentation followed by filtration, two using irrigation and one employing sedimentation and shallow aerating beds. The plants in connection with public and private institutions show a similar variety of types. Some of the plants are of the latest types of their kind, and if they are properly managed should furnish results of much value in demonstrating what can be accomplished by complete and incomplete systems of treatment. Dr. E. H. Porter, Commissioner of Health, has had every one of these disposal plants examined, and a report containing a description with plans and photographs of each plant has been prepared. It is the intention to keep them under continual observation and to make systematic analyses of the raw sewage and effluent, so that the efficiency of the plants, their special features of design, and the differences in the character of the sewage treated and effluents obtained may be fully determined. The purpose of carrying on this research is to obtain as much information as possible concerning sewage disposal under New York State conditions for the guidance of municipalities and institutions which may hereafter have to construct similar plants.

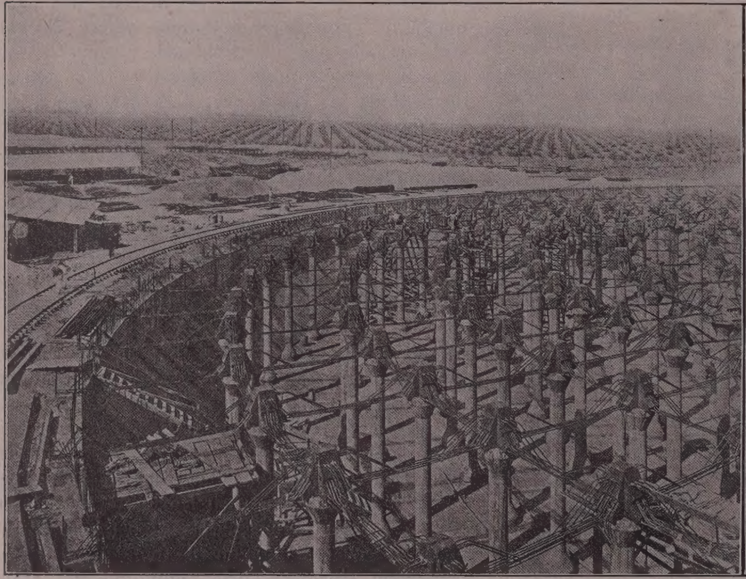
THE OPTIMISTIC NEWS which has appeared in the better class of daily papers during the last fortnight has a manifestly sound basis. Allowing for the usual inaccuracies that creep into print when news is written hurriedly and not revised by those giving it out, the fact remains that there has been a somewhat general increase in the number of men employed in different industries and either a return to full working hours or notices of such a return in the near future. Of course there are some industries which have not shown these conditions; for example, in New York City and its immediate vicinity, there is little probability of an early resumption of the construction of large buildings, although residences and small business structures costing up to about $75,000 seemed to be planned in about the usual number. These local situations where dullness still prevails can be explained, however, from natural causes entirely independent of a general depression; in New York there has been a fall in the rate of rental in office buildings which well accounts for the lack of interest in such structures at the present time. Another sign of the times which is most significant is the general rejoicing in the recent decision of the United States Supreme Court which declares invalid the State legislation in North Carolina and Minnesota regarding railroad rates. This decision, coming so soon after that of the United States Circuit Court to the effect that the 80-cent gas rate law in the State of New York was confiscatory, proves that the money of the thousands of people who have invested their savings in securities of public service corporations is safe against ill-advised legislation. This journal has never held the opinion that such legislation was based on anything but a misapprehension of conditions and consequently on an ill-founded plan for remedying situations that really did not exist. Had public service corporations shown more tact in dealing with the public, it is safe to say that a great deal of the trouble we have been going through would have been avoided, but the gratifying fact is everywhere evident that these corporations have at last awakened to a realization of the obligation they are under to make public their affairs. Even companies which are not in any sense public service corporations are beginning to see the importance of this step, as a simple means of insuring public confidence in their securities, and only this week the American Sugar Refining Co. for the first time in its history published a fairly complete statement of its business affairs during its last fiscal year. Of equal importance with all these cheerful indications of a return of times of less anxiety, is the news that Congress will probably repeal the Sherman anti-trust law, a measure that was known to be a temporary expedient when it was passed, has been long a source of irritation to many interests, and is directly responsible for some of the troubles we have recently been having. When it has been replaced by a law which will better fulfill the perfectly proper intentions of those who framed the Sherman act we will be relieved of restrictions which have proved as ill-advised in some respects as the anti-railroad legislation of some of the States.

La Noria Pumping Station.

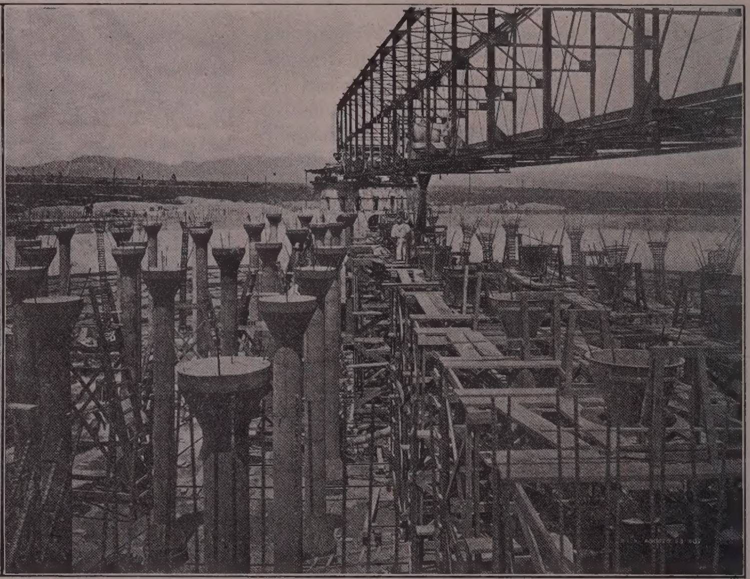
The Reinforced Concrete Reservoirs and Aqueduct of Mexico City.

By James D. Schuyler, M. Am. Soc. C. E., Consulting Engineer, Los Angeles.

The most extensive, ambitious and highly scientific work in the way of reinforced concrete construction in progress in the Republic of Mexico to-day is the building of four large circular reservoirs, lined and roofed with armored concrete, for the distribution system of the new waterworks of Mexico City. The works have been designed and are being built under the direction of Manuel Marroquin y Rivera, M. Am. Soc. C. E., who bears the title of "Director Tecnico de las Obras de Provision de Aguas Potables para la Cuidad de Mexico," to whom the writer is indebted for the information and illustrations accompanying the following description, prepared after a recent visit to the works.



View of Column and Girder Reinforcement.



Bridge Used in Filling Column Molds.

The reservoirs are four in number, each having a capacity of 50,000 cubic meters (13,237,500 gal.) located on the high plains to the west of the Castle of Chapultepec, on the historic battlefield of Molino del Rey, at an elevation of 52 meters above city datum, the lowest level of the reservoirs at the center being about 42 meters higher than the streets of the city, while the high water level is 59 meters above city datum. They are circular in form, 105 meters in diameter at the top and 96 meters in diameter at bottom. The maximum depth of water they are to contain is 7 meters (about 23 ft.)

The bottom slopes toward the center at the rate of 2 per cent, while the roof slopes away from the center on an inclination of 2.5 per cent, and is elevated at the center sufficiently to give a clear space of 4 ft. beneath the bottom of the beams above the water line. The roof is to consist of a slab of reinforced concrete, 6 in. thick, supported by radial and concentric beams, resting on cylindrical pillars of concrete, properly reinforced, the whole surface to be covered with 20 in. of soil, sodded, and converted into a public park.

In the center of each reservoir is an octagonal tower, 3 meters in diameter, reaching to the roof, from which all the primary beams radiate to the exterior. Above the roof line this tower changes to a circular form, terminating at a height of 13.85 meters (45.43 ft.) above the roof in an ornamental electrolier. A stairway in this tower gives access to the reservoir. Its base is placed at a depth of 4.6 meters below the floor. The sole inlet and outlet of each reservoir is through a circular pipe of reinforced concrete, 1.5 m. (59 in.) interior diameter, which passes underneath the floor, and terminates in the interior of the central tower, the center of the pipe being 1.85 m. below the top of the reservoir floor at the tower.

There are no gates or screens in these towers, but all of the controlling devices are in a central gate house where all the pipes from the reservoirs center. A system of gates in this distribution center permits of a complete intercommunication between each reservoir and the central pumping station from which all are fed from the main aqueduct, and also direct connection from each reservoir to the distributing mains of the city.

Excavation.—The greater portion of each of the reservoirs is excavated below the natural surface of the gently sloping plain on which they are placed. After removing the thin layer of vegetable mould soil on the surface, one to two meters in depth, the remaining excavation was in a volcanic tufa formation, locally known as "tepetate," which is a soft rock, answering to the description of "hardpan." This material can be trimmed to true lines and slopes, and stands well at a 1 to 1 slope. This material, though quite hard, is porous, and requires to be lined on the bottom and slopes with a layer of reinforced concrete. Wherever the tepetate did not reach to the top of the reservoir, it was stripped of all covering to a considerable width and a heavy mass of concrete built up to the height of the base of the vertical wall which forms the periphery of the reservoir and is 3 meters in height. This foundation wall is of variable height, and is 2 meters thick at the top, and 3 to 3.5 meters thick at the bottom, formed of 1 part of cement, 2 of hydraulic lime, 6 of sand and 8 of broken stone, all materials being measured by volume.

The vertical wall about the periphery of the reservoir is 12 in. thick, reinforced with vertical and horizontal rods, and strengthened by counterforts at the intersections of the radial roof beams, at intervals of 5.15 meters. From the base of the vertical perimeter wall to the bottom, the sides slope 1 on 1, and are covered with 8 in. of concrete, reinforced with ½-in. square corrugated bars 12 in. apart in each direction. This lining is being applied with great care, and expansion joints are placed at intervals to take up shrinkage and movements due to variations of temperature. It is intended to fill these joints with asphaltum and cement, to be followed by a coating of asphaltum, covered with a layer of concrete slabs in case it becomes necessary.

The lining of the first reservoir has been completed for several months, and though exposed to the sun without protection other than to sprinkle it daily it shows no cracks whatever.

The floor of the reservoir has a system of reinforced beams, radially and concentrically placed to correspond with the roof beams.

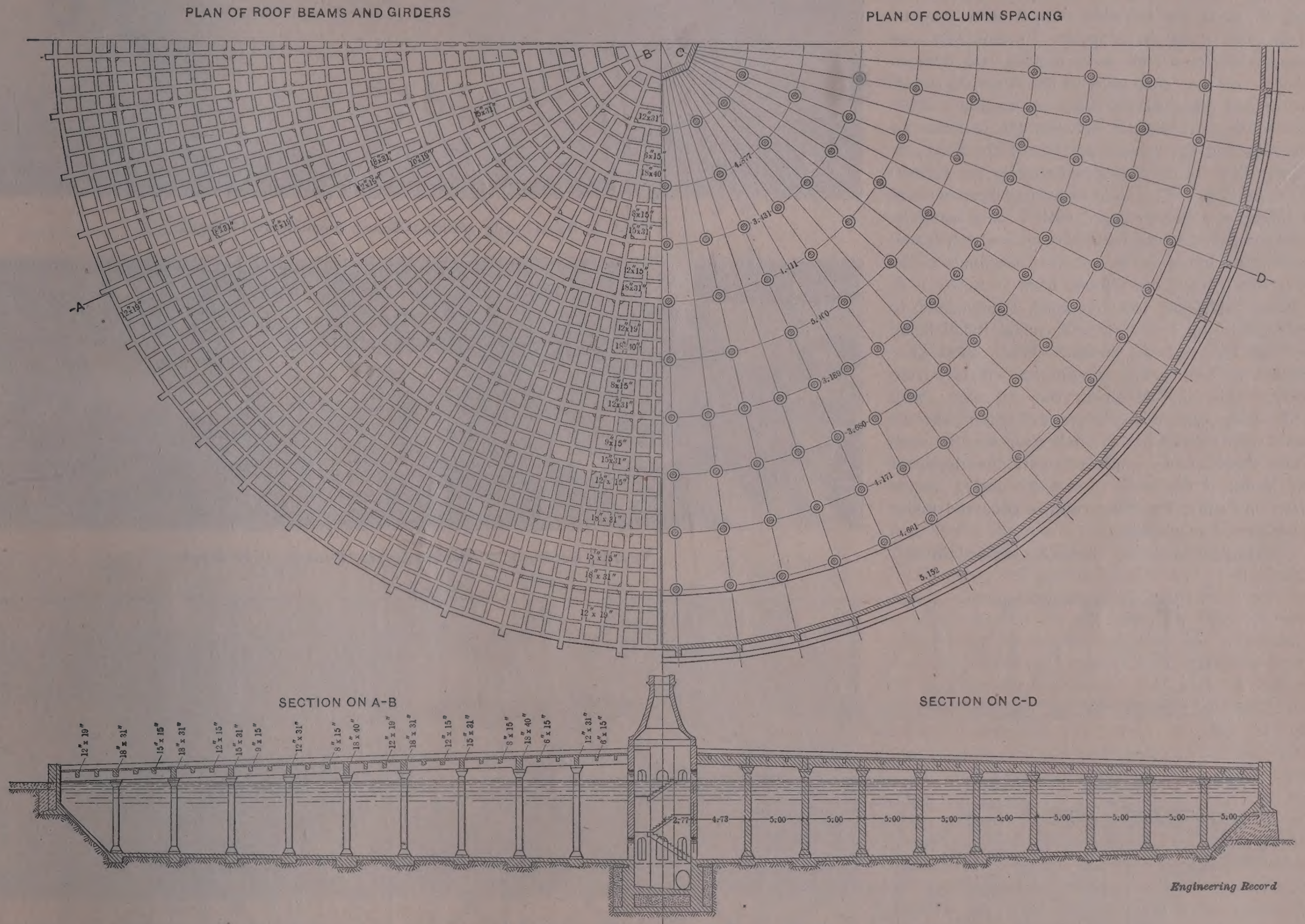
Columns.—The columns supporting the roof are placed at even distances of 5 meters, center to center, from the middle to the perimeter, while in a concentric direction the least span is 3 meters and the maximum 5 meters. They are all hooped with steel bands, having a least section of ⅛ x 1 in., riveted with two 5/16-in. rivets. The distribution of these hoops was determined after careful investigation and actual test. The spacing in each column was computed by the formula: $P = 25{,}000na.$, in which P is the difference in excess of the actual load on any column over 70,000 lb.; n is the number of hoops per lineal meter, and a is the area in square inches of the hoops, assuming that the concrete of a column will carry by itself a load of 300 lb. per square inch. The excess over that load would be borne by the hoops, the metal in them being 2½ times the amount required for longitudinal reinforcement. It was also assumed that the metal if employed longitudinally should not have a greater strain than 7,500 lb. per square inch, which is one-fourth of the elastic limit of 30,000 lb. In no event, even if no hoops were used, should the column be required to support more than 600 lb. per square inch.

The ratio between the height and diameter of the column is 13.5:1 in the most unfavorable case, or 16.25:1 taking the full height, including base and capital. The hoops, besides giving additional stiffness against failure under extreme load, are of value in case of any eccentricity or shock.

Girders.—The girders were all computed as supported. The formulae for calculating breaking load were taken from those given in the Corrugated Bar Co.'s catalogue for 1:3:6 concrete, and then a reduction of 1 to 4 was admitted for the working load, except for the radial beams. In this case, taking into consideration their continuity in straight lines, a reduction of 1 to 3 was only admitted. After computation of moments, diagonal tension was examined and some of the rods were bent in 45 and 30 deg. angles; the projection of shear on the rods was considered and a tension of 18,000 lb. per square inch was admitted.

The concrete section in each girder was so proportioned that the shearing strain divided into 0.87 area of cross-section should in no case exceed 60 lb. per square inch.

Construction.—The molds for the concrete columns were made of sheet steel, ⅛ in. thick, reinforced with 2-in angles, and made in convenient sections for bolting together. The molds for slope-linings and walls are all formed of wood, well surfaced and painted to give clean inner surfaces. All these molds have longitudinal grooves, ½ in. wide and about ¾ in. deep, to prevent the warping and distortion of the wood in the hot sun. This precaution has been quite effective. They are substantially made, and stiffened with steel angles to hold them in true form and shape.



General Arrangement of Columns, Girders and Beams in One of the Reservoirs.

All the concrete is mixed with the Smith revolving mixers of ½ cu. yd. capacity. The proportions used throughout are 1 cement, 3 sand and 3 crushed basaltic rock or gravel. The cement used is the English Gibbs Portland except in the roof girders and slabs, where German Dyckerhoff is to be employed. Most of the sand is taken from a natural deposit found near the reservoir site at a depth of 7 meters below the surface, where an inexhaustible quantity of clean, sharp, andesite sand is obtained of most excellent quality, with all sizes of grains from ¼ inch diameter to fine dust that will pass through No. 100 mesh sieve. A part of the sand is produced by grinding crushed basalt in a rotary centrifugal mill of local invention called the "Niagara disintegrator," by which the sand is produced at a cost of $2 Mex. per cubic meter. This machine takes the run of rock from the crusher and converts it into sand at the rate of about 5 cu. m. per hour, with not to exceed 6 h.-p. A series of loosely hung hammers of case-hardened cast steel are revolved at a high speed through the stream of rock fed into the machine, causing the particles to strike each other and against the hard steel plates with which the box is lined.

The rock-crushing plant is located at a distance of 14 kilometers from the reservoirs on the line of the aqueduct, from which it is brought by rail. All stone used is passed through a 1¼-in. screen.

The reinforcing material consists of square corrugated bars, supplied by the Expanded Metal & Corrugated Bar Co., of St. Louis. The bars are specified to have a limit of elasticity not less than 50,000 lb. per square inch.

Revolving Bridge.—One of the many ingenious devices designed for the rapid and economical delivery of concrete to all parts of the reservoir for forming the floors, columns, girders and roof is a revolving steel bridge, which spans the distance from the central tower to a circular track on the exterior of the outer wall. The bridge, which is more properly a revolving crane, has a total length of 187 ft., and revolves on a pivot placed on top of two flat cars on the central tower. The outer end rests on a flat car on the exterior circular track. On this end of the bridge two ½-yd. concrete mixers are established, with independent steam power and elevators for delivering the aggregates to each mixer. The mixed concrete is discharged by gravity into two barrels of the same capacity as the mixer, one for each mixer, mounted on a carriage that runs on a 28-in. gauge track along the bridge. The barrels are moved along the bridge to any point desired by means of a continuous cable actuated by the 30-h.-p. engine which also drives the mixers and elevator. These barrels are provided with hand-cranks and gearing by which they may be revolved, and the concrete remixed, if for any reason it is not quickly discharged from the barrel. By these cranks, also, the barrels are turned over so as to discharge into the movable hopper, placed underneath and moved to any point of delivery desired along the lower chord of the bridge. From this movable hopper, to which flexible steel or canvas pipes are attached, the concrete may be delivered into the top of any one of the column molds, or into the girder molds.

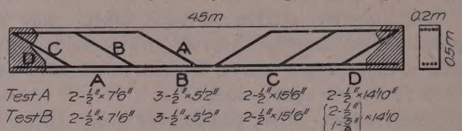
The bridge will be used for all four of the reservoirs, one after the other, as completed, and the column molds will be successively used. Molds for one-fourth the area of one roof only will be provided, and thus they will each be used sixteen times before they have completed their serviceability.

In the building of such a massive roof over so large an area as each of these reservoirs presents, the question of sustaining the forms during the time required for the setting of the concrete was one of the most serious problems to be solved. To build up timber supports of requisite stiffness and stability reaching from the floor to the roof, on account of the height, would have required a vast forest of timber, of little subsequent utility, and costly to erect and remove. It was finally determined to suspend the forms from the tops of the columns by a series of steel I-beams of standard sizes and lengths which would have a market value for building construction of at least 75 per cent. of their cost after the works were completed. But in order to place the top series of I-beams high enough to act as suspensors for the forms of the main reinforced concrete beams it was necessary to build up the capitals of the columns to the ultimate height of the top of the roof as bases on which to rest the temporary hanger beams, and in these concrete capitals, which form the ends of four intersecting concrete beams, mold all the steel reinforcing rods subsequently required for the concrete beams. This in effect meant the formation of the ends of the beams a long time prior to their ultimate completion. Hence to determine the effect of this composite construction of a beam, with a joint near each end, upon the final strength of the beam, a series of tests were made in the Condesa testing laboratory, with four full-size beams reinforced as they are to be used in the roof of the reservoir. Two sets of tests were made, with two beams each, 14 and 28 days after molding. These beams were 14 ft. 9 in. long, 19⅝ in. deep, 7⅞ in. wide, with a clear span of 13 ft. 1 in. between supports. In one beam of each set the two ends were molded two days in advance of the remainder, in the form shown by the shaded areas of the diagram, leaving a well-defined line of jointure between the concrete of the ends and the central portion of the beam.

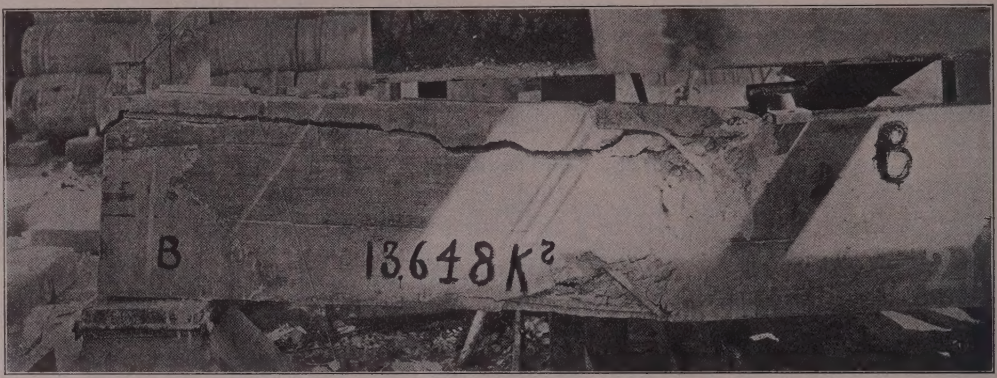
Test A, at 14 days, was made under the following conditions: The solid beam had been molded complete at one operation, with 1:2:3 concrete, reinforced at bottom with two square corrugated bars ½ in. by 14 ft. 10 in.; two diagonals ½ in. by 15 ft. 6 in., three oblique bars ½ in. by 5 ft. 2 in. at each end, and diagonals, from center to ends, ½ in. by 7 ft. 6 in., the metal in all being 0.7 per cent. of the beam. With 3,809 kilos applied at two points at one-half meter from central axis, the deflection was 2.4 mm.; with 6,185 kilos applied load, the deflection was 4.6 mm.; with 10,369 kilos the deflection was 8.2 mm., when three cracks appeared, half the depth of the beam, at distances of 1.5, 2.9 and 3 meters from one end. The final rupture occurred under a weight of 11,460 kilos.

The second beam of the pair, molded in sections as described, showed a deflection of 2.4 mm. under 3,908 kilos, 4.8 mm. under 6,815 kilos and 8.0 mm. under 10,369 kilos, when four cracks appeared, 20 cm. long, at distances of 1.5, 1.7, 3.0 and 3.1 meters from one end, all inclining toward the load. The final rupture took place with a deflection of 20 mm. under a load of 13,648 kilos without the slightest sign of weakness appearing at the joints in the concrete. The ruptured beam is shown in one of the illustrations.

Test B, at 28 days, gave results quite in parallel with those of Test A. The mixture was the same, but the reinforcing metal was greater, amounting to 1.0 per cent. of the beam, consisting of three straight base bars in bottom, two of which were ½ in. square and one ⅝ in. square, 14 ft. 10 in. long; also two base bars with diagonal to top at ends, each ½ in. square and 15 ft. 6 in. long; three intermediate top and diagonal bars at each end, each ½ in. square and 5 ft. 2 in.

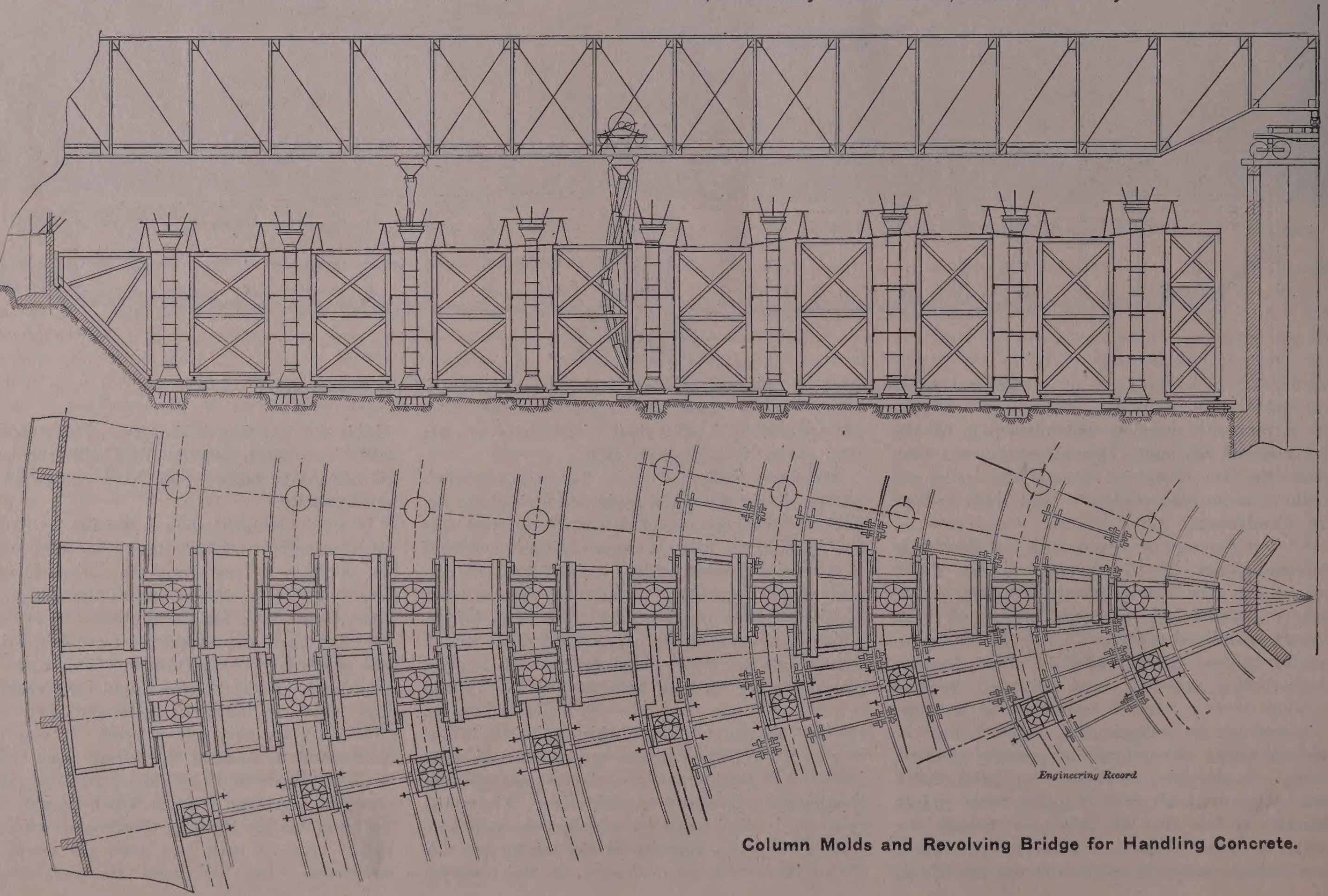

4.5m
0.2m
0.5m
C
B
A
D
A
B
C
D
Test A 2-½"×7'6" 3-½"×5'2" 2-½"×15'6" 2-½"×14'10"
Test B 2-½"×7'6" 3-½"×5'2" 2-½"×15'6" {2-½" 1-⅝"}×14'10

Reinforcement in Tested Beams.



Test A, Sectionally Molded Beam, Broken at 14 Days.

Test B, Sectionally Molded Beam, Broken at 28 Days.


Engineering Record

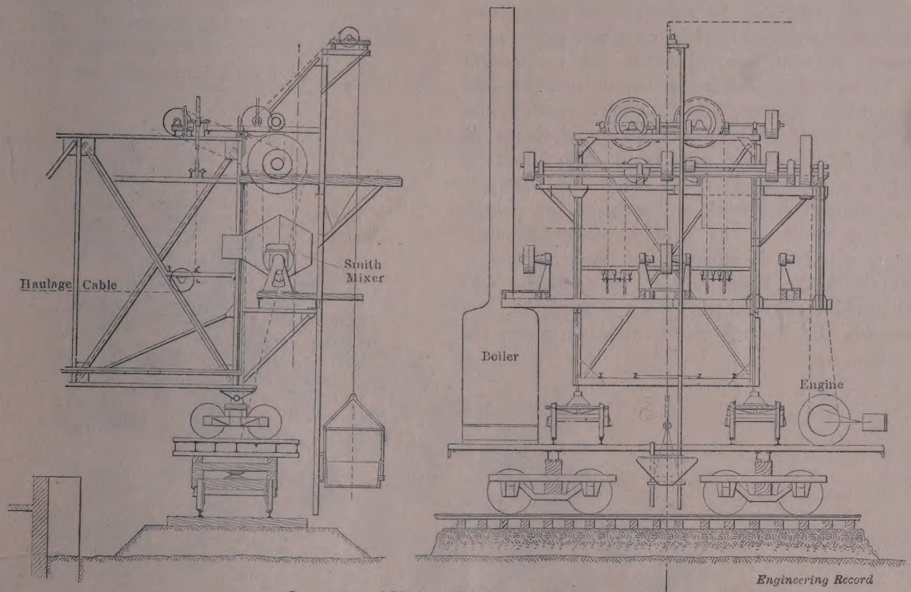
Column Molds and Revolving Bridge for Handling Concrete.

long, and two central diagonal and top bars, each ½ in. square and 7 ft. 6 in. long.

The beams showed the following comparative results during test:

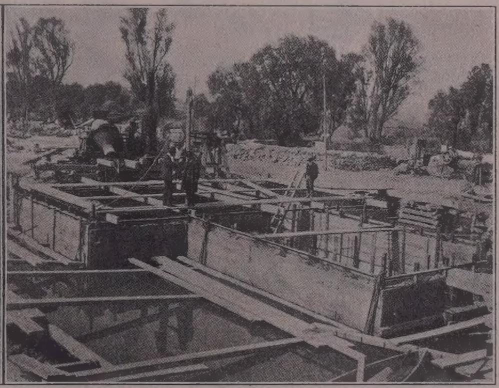
Applied load. Kilos.	Solid beam. Deflection.	Beam molded in sections. Deflection.
3,809	2.0 mm.	1.8 mm.
6,815	3.0 mm.	3.2 mm.
10,369	7.0 mm.	5.6 mm.
12,556	10.0 mm.	7.2 mm.
14,742	13.0 mm.	8.8 mm.
16,929	22.0 mm.	10.2 mm.
18,018	Ruptured by compression.	
19,116	....	12.4 mm.
21,299	....	16.4 mm.
22,390	....	Ruptured by compression.

In each beam cracks began to appear under a load of 10,369 kilos. The appearance of the sectional beam after rupture is shown in one of the pictures.



Concrete Mixing Plant at End of Bridge.

Opening at Expansion Joint, Subsequently Filled with Concrete.



Reinforced Concrete Caisson in La Noria Spring Pumping Pit.

In this case, also, the absence of any cracks or sign of weakness on the line of joints between the older and newer portion of the concrete beam seemed to prove conclusively that there was no weakness to be feared from this fragmentary method of molding as compared with the monolithic beams, but, on the contrary, they developed greater strength in each case.

An illustration on page 362 shows very clearly the capitals formed on top of the columns, with reinforcing rods placed from each in four directions to form the primary radial and concentric beams. The revolving bridge with its suspended hopper and barrel-car for transporting concrete is shown by the illustration on the opposite page. In this picture, the movable staging to support the column molds and give ready access to the top of the columns is also shown. These platforms are provided with small wheels, and are moved along on circular tracks placed between the rows of columns.

Ventilation.—The minimum height between the roof slab and the maximum water level is nearly 3 ft., and a free circulation of air is provided in the plans by circular openings between the beams through the perimeter wall, and openings in the central tower below the roof line as well as at a considerable height above.

Plans.—One of the accompanying illustrations gives a complete cross-section of the reservoir, a quarter plan of the column distribution, and a quarter plan of the roof system of beams. Another drawing gives a partial plan and section of the columns, showing the movable platforms supported on circular tracks, and the method of delivering concrete from the bridge. Another picture shows the arrangement of mortar mixers and elevators on the outer end of the bridge.

It is not anticipated that the first of the four reservoirs will be put into service till about the end of 1908.

The Conduit.—The main conduit has been practically completed from La Condesa pumping station, near Chapultepec, to the nearest of the four pumping stations at La Noria, a distance of 20 kilometers. The pumps and motors at this station have been installed and the aqueduct can be utilized for the delivery of about 300 liters per second, which La Noria springs will supply, as soon as the finishing touches are given to the acqueduct. This volume of water will be delivered to the old Chapultepec reservoir, which bears the venerable date of 1573 A. D., by means of existing pumps, and thence fed into the present city mains to eke out the small supply now available. The new reservoirs and the full aqueduct supply will not be made available until an entirely new system of cast-iron distributing pipes is laid throughout the city. As this work has not yet begun the new supply can only be utilized in small part on account of the inferior size and inadequate capacity of the present pipes, which will be entirely abandoned after the new ones are laid.

Over the greater portion of the distance the new aqueduct was laid in ground so solid that no cracks have appeared, and there is no sign of leakage either from the aqueduct or into it from the surrounding ground water, but in two sections of 4 and 2 kilometers, the latter from the lower end up, serious settlement has taken place, amounting to as much as 12 in., and a large number of cracks have appeared, always at the joints between one day's work and the next, or at intervals of about 40 meters. This settlement and the cracks first made their appearance after the notable earthquake of April, 1907, and the amount of the settlement at different places was determined by subsequent check levels. Until the settlement is stopped and the cracks are effectively closed the conduit cannot be put into service, and it is this problem which now gives Mr. Marroquin most serious concern.

The phenomena accompanying this action are extremely interesting and illustrate the extraordinary difficulties encountered oft-times by engineers in volcanic countries and little dreamed of by constructors in more stable parts of the world.

The valley of Mexico was once a lake which occupied what might have been a colossal crater, and the soil with which it was subsequently filled to its present level consists in large part, particularly at the lower levels, of volcanic ashes, pumice and scoriæ, deposited in water. Much of the pumice is of extremely light specific gravity, and resembles a sponge in that it will take up as much as 80 per cent. of its bulk of water. This pumice is found in layers from 5 to 20 meters below the surface, covered by alluvial soil washed down from the mountains. The theory which Mr. Marroquin has evolved as the result of his borings and the study of this material, is that so long as the surface is not materially disturbed by extensive excavations it remains in a state of equilibrium and sustains the weight of soil upon it, but when a deep trench is made in it and the material thrown to one side the light subsoil, relieved of its weight, absorbs more moisture than the normal and swells. Then when the backfill is made, the increased load tends to squeeze out the moisture of the sponge sufficiently to allow of material settlement. A piece of this pumice stone from a bore-hole, even after lying in the sun some hours, will yield up water quite freely when squeezed in a cloth, as tested by the writer recently, which appeared to prove the accuracy of Mr. Marroquin's theory. The settlement in all cases was found to be greatest where the conduit passed under small river channels, confined in their passage across the valley by high dykes or levees. Here the excavation had been made through the dykes, the conduit built and the backfill restored, and thus a maximum relief given to the subsoil and the greatest amount of subsequent loading. That the settlement is not due to any additional weight imposed by the conduit is proved by the fact that the conduit, when filled with water and backfilled to the established grade, weighs no more than the earth removed from the trench.

It has been found by boring along the conduit that the depth to solid gravel or hardpan is from 35 to 45 meters. The remedy which Mr. Marroquin now proposes to apply is to drive wooden piles at each side at intervals of 4 meters, these piles to be built up of 10 x 10-in. square timbers, bolted together in sections and driven in pairs on each side of the aqueduct, down to solid foundation, and on these to place reinforced concrete collars or cross beams to support the aqueduct. At the same time, overflow weirs will be built at such intervals as to prevent the aqueduct from ever having a greater head than 1 ft. above the top, relieving all possible hydrostatic pressure.

The places where cracks have appeared will be surrounded by a heavy collar of best puddled clay to keep ground water from reaching the conduit, and, at the same time, have a certain small amount of flexibility. The cracks will further be repaired from the interior. They are all small and do not leak any serious amount. At the time of the earthquake the conduit was full of water, but did not leak materially after.

The outcome of this work will be watched with much interest, especially by those members of the American Society of Civil Engineers who visited the aqueduct during the last annual meeting in June, 1907, and thus became familiar with the situation.

La Noria Pumping Station.—One of the many novel and interesting features of these works was the method adopted for sinking the caisson foundations of the pumping station in the big spring of La Noria. It was desired to place the floor of the pump house some 4 meters below the normal water level of the spring. To exhaust the water so as to place the foundations on dry ground was practically impossible, so the cavity was excavated with an orange-peel dredge to a size of about 50 x 90 ft. and a similar excavation was made adjoining at a higher level, surrounded by levees, where the caisson of reinforced concrete was built with great care on dry ground. Then water was admitted to this artificial basin by breaking the levee between it and the spring pond, the caisson was floated laterally into position like a barge, the sides were built up, and the whole ponderous structure finally sunk in its true position. Subsequently a steel tank was built inside, and an inner lining of concrete placed inside the tank. The pumping station built over this station is shown in perspective on page 362.

The next pumping station, at Nativitas Springs, 5 kilometers beyond La Noria, will supply about 700 liters per second. Two others will be built 2 to 3 kilometers to the south, the furthest of which, 27 kilometers from the city of San Luis, will supply about the same volume of water as Nativitas Spring.

The total supply derived from the four stations is expected to amount to about 2 cubic meters per second (45,600,000 gal. in 24 hours).

The conduit is now nearly completed to Nativitas Spring, and, as heretofore stated, wherever it is on rock, or gravel or earth away from the lake bed formation of the valley, the work has proved faultless and entirely free from cracks or settlement.

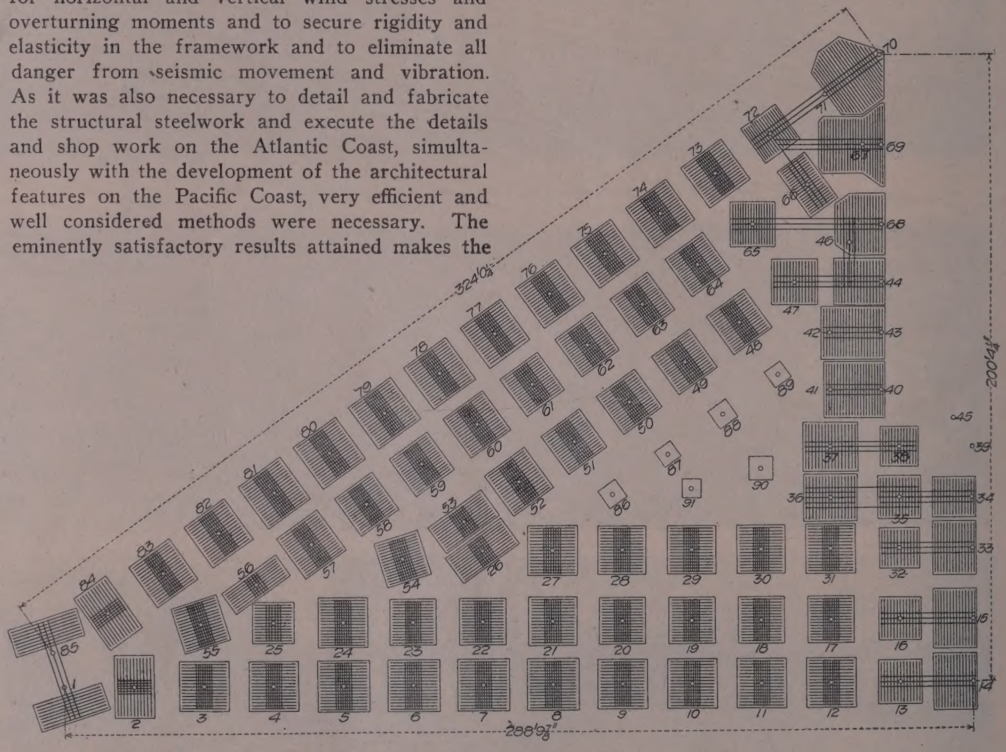
The cost of the concrete work in the conduit and reservoirs is said to average about $25 Mex. per cubic meter, including the elaborate steel reinforcement, forms, etc. This is equivalent to about $9.60 gold per cubic yard.

MAGNETIZED WELL CASINGS are responsible for the magnetic properties attributed to the waters of many so-called magnetic springs and wells, according to investigations by the U. S. Geological Survey, which show that the waters do not have magnetic properties. The magnetism of the casings is sometimes sufficient to hold only small nails, but is frequently strong enough to hold bolts and spikes. A casing at Grayling, Mich., was so strongly magnetized that a man could with difficulty start to the surface a 2,600-ft. steel tape which weighed only 25 lb., and in a well at Cheboygan, Mich., the magnetic drag was so great that the driller could not tell when a 20-lb. weight reached the bottom. The fact that many pocketknives are in themselves more or less magnetic is also responsible for the reputation of the waters, according to the report, for they are frequently used to demonstrate the magnetizing effect by being thrown into the waters.

The Phelan Building, San Francisco.

The 11-story Phelan Building at the intersection of Market and O'Farrel Sts., San Francisco, occupies an approximately triangular site about 296 x 329 ft. in extreme dimensions. The wide end is about 205 ft. wide and the 13-ft narrow end is rounded in plan to a radius of about 6 ft. with the curved walls tangent with the straight faces on the two street fronts. The steel framework has a total height of about 146 ft. above the curb and extends to a maximum depth of 25 ft. below it. There are two columns running to the second floor only, six to the third, and 81 full length columns spaced from about 20 to 23 ft. apart longitudinally and transversely.

The estimated total live and dead load of the building is 50,326 net tons and as it is supported on sandy soil comparatively near the surface of the ground and may be subjected to earthquake shocks of considerable violence, great pains were taken to prevent unequal settlement, to provide for horizontal and vertical wind stresses and overturning moments and to secure rigidity and elasticity in the framework and to eliminate all danger from seismic movement and vibration. As it was also necessary to detail and fabricate the structural steelwork and execute the details and shop work on the Atlantic Coast, simultaneously with the development of the architectural features on the Pacific Coast, very efficient and well considered methods were necessary. The eminently satisfactory results attained makes the structure notable in many respects, exclusive of the interesting foundation work in which difficult problems have been solved by some original methods of construction and the application of simple and efficient details.



Grillage Plan of Phelan Building, San Francisco.

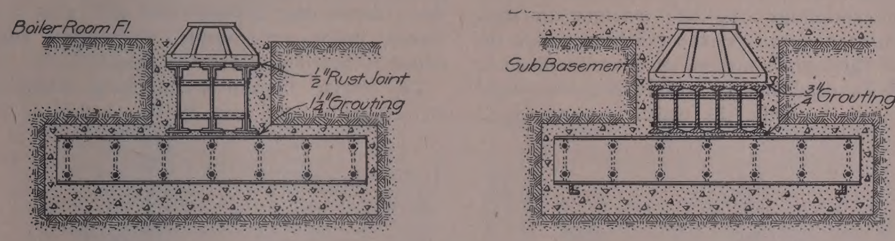
The weight of the building and its contents produces maximum concentrated column loads of 1,473,000 lb. which are reduced to the allowable load per square foot on the soil by the interposition of rectangular I-beam grillages with concrete footings at depths varying from about 24 to 30 ft. below the surface of the ground. Most of the grillages are about 15 ft. square and are made with two crossed tiers of I-beams from 18 to 24 in. in depth, the upper tier serving as usual for distributing girders and receiving the column loads through their pedestals. Both I-beams and pedestals are entirely enclosed in concrete with its upper surface below the cellar floor level. The total loads carried are so great that a large area is required for the footings and together they cover over one-half of the total area of the building with the exception of a triangular space in the center of the building having an area of about 4,500 sq. ft. under the light court where there are six short auxiliary columns with small concrete footings.

In the preliminary calculation a maximum load of 6,000 lb. per square foot from combined live and dead loads was allowed for the grillage footings on the fine dry sand. As some of the columns, notably the wall columns and those supporting the boilers, have a much higher proportion of dead load than of live load it was believed that on the above basis their settlement might not be regular with that of the other columns and the footings were therefore redesigned on a basis of a maximum dead load pressure of 3,700 lb. per square foot, which is the minimum load pressure that was established on the foundations as previously designed on the basis of 6,000 lb. per square foot for dead and live load combined, thus considerably increasing the area for the wall column footings.

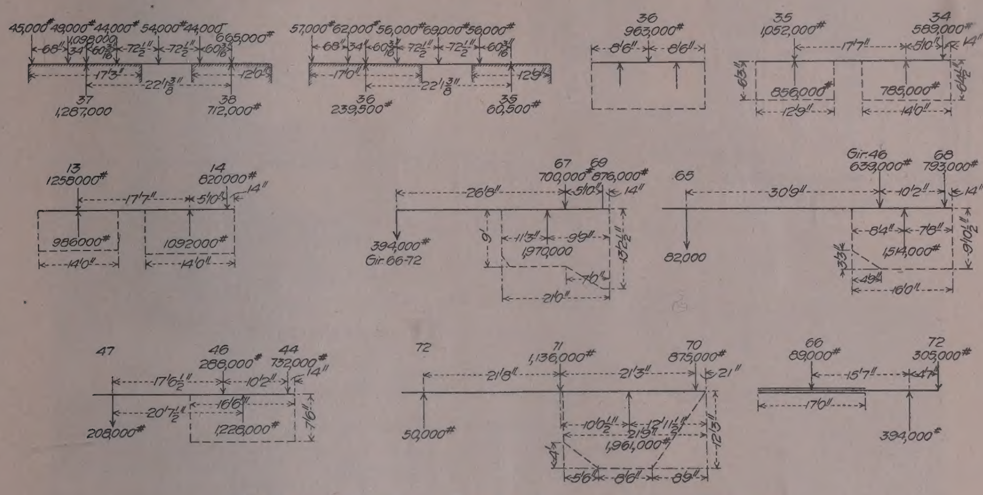
The footings supporting the elevator machinery and the boilers, required to be made at a level several feet lower than those of the other columns and in order to avoid unnecessary excavation and unnecessary extensions at the lower ends of the other columns, the different footings were placed at levels determined by a slope of 1 vertical to 1½ horizontal, arbitrarily taken in every direction from the bottoms of the lowest excavations required. It was assumed that the stability of the soil lies within this slope and that the foundation pressures will be safely distributed below the surface regardless of the varying height. This construction necessitated considerable irregularity in the lengths of the basement columns and developed some complication in the different levels, but was considered to be well justified by the considerable economy in the weight of steel and in the amount of excavation effected.

The dimensions of the footings for the interior columns and the number and dimensions of the grillage I-beams vary somewhat, and the general arrangement corresponds to that indicated in the plan for column 28, which has a maximum load of 1,188,000 lb., and is seated on a cast-iron pedestal with a grouted bearing on eight 24-in. 80-lb. distributing beams 14 ft. long transverse to the bottom tier of fifteen 18-in. 55-lb. I-beams 14 ft. long. On the two street fronts the footings for the intermediate wall columns correspond closely to that for interior column No. 28, while those at the corner and on the side of the lock adjacent to the party wall are made special.

All footings are made with a bed of concrete 12 in. thick and 12 in. wider and longer than the dimensions of the first tier of grillage beams. In the upper part of the concrete there are two full-length rectangular grooves transverse to the lower tier of grillage beams. In each groove a 3 x 3 x 5/16-in. angle was carefully leveled with the upper edge of its vertical flange truly horizontal and ¾ in. above the surface of the concrete. These serve as leveling bars to receive the lower flanges of the grillage beams and insure their exact height. The spaces between the beams and the concrete footings were grouted, the second tier of beams was shimmed ¾ in. above the top flanges of the lower tier and grouted, the cast-iron pedestals were set ¾ in. above the top flanges of the distributing beams and grouted, and a solid mass of concrete was filled in 6 in. around the outer edges of the beams and pedestals and up to the cellar floor completely enclosing and protecting all of the substructure steel work.



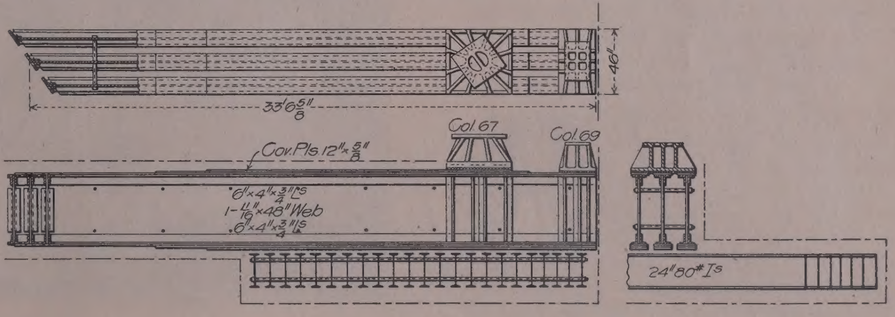
Footings with Plate Girders and Double Tiers of I-Beams.



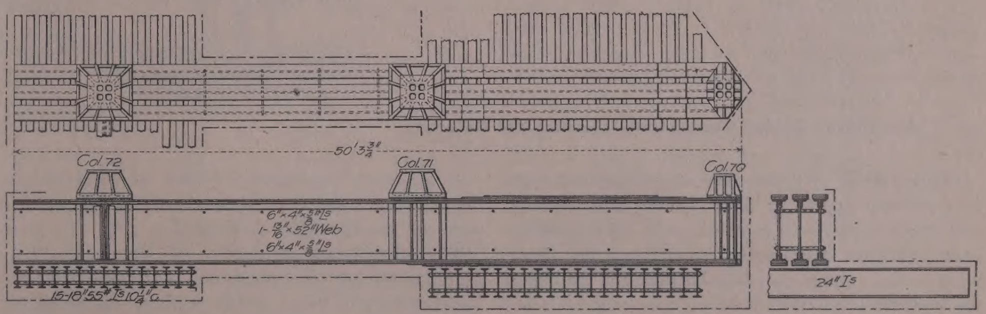
Loads and Reactions of Special Footings and Girders.

Cast-iron pedestals and rust joints have been used on columns 13, 16, 35, 36, 37, 38, 41, 42, 46, 47, 65, 66, 67, 71 and 72. These are interior columns adjoining the party line, where a comparatively small base rests on top of plate girders. Cast-steel pedestals and rust joints have been used on columns 14, 15, 33, 34, 40, 43, 44, 68, 69, and 70. These are columns along the party line, where only a very narrow pedestal could be used, which, for the sake of strength, had to be made of cast steel. In all other cases cast-iron pedestals and grouting have been used, with the exception of columns 1 and 85, where a riveted base was introduced. The six short columns under the light court have cast-iron pedestals seated directly, without the intervention of grillage beams, on concrete footings from 6 to 8 ft. square.

All of the columns in line 13-34-38-40-70, adjacent to the party wall, are set so close to the building line that direct connections to the footings would impose eccentric loads on the latter, therefore, in order to transmit their loads through the centers of gravity of the footing, recourse has been had to the standard expedient of seating the wall columns on the short ends of cantilever girders with their long arms anchored to intermediate columns. This arrangement was very simple for wall columns 14-15-33-34-38-40-43, all of which were seated on the extremities of simple triple-web plate girders, which at the other ends supported the adjacent interior columns. All of these girders were made with three web plates 39 in. deep, with 6 x 4-in. flange angles, and six or more 12-in. cover plates on the top and bottom flanges. The web plates vary from 9/16 to 13/16 in. in thickness, the angles from ⅝ to ¾ in., and the flange plates from ⅝ to ¾ in. In most places the length of the cantilever arm is 5 ft. 10 in., and that of the anchor arm 17 ft. 7 in.



Cantilever Girder with Indirect Reaction.



Girder under Corner Columns.

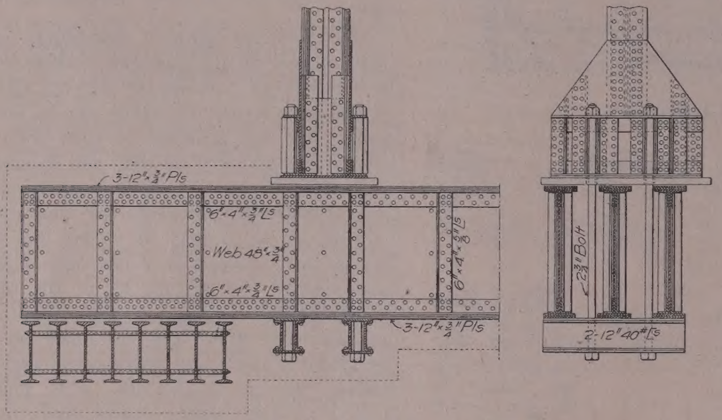
Wall column 38 is concentric with its footing and, therefore, independent of any cantilever girder support, but as the distributing girder which transmits the 655,000-lb. load to the grillage also carrier boiler loads, it is made continuous with the distributing girder, which receives the 1,096,000-lb. load from the adjacent interior column No. 37 and thus distributes the main column loads above mentioned, together with boiler loads of 45,000 lb., 44,000 lb., 54,000 lb. and 44,000 lb., uniformly over both grillages, making total loads of 1,287,000 lb. and 712,000 lb.

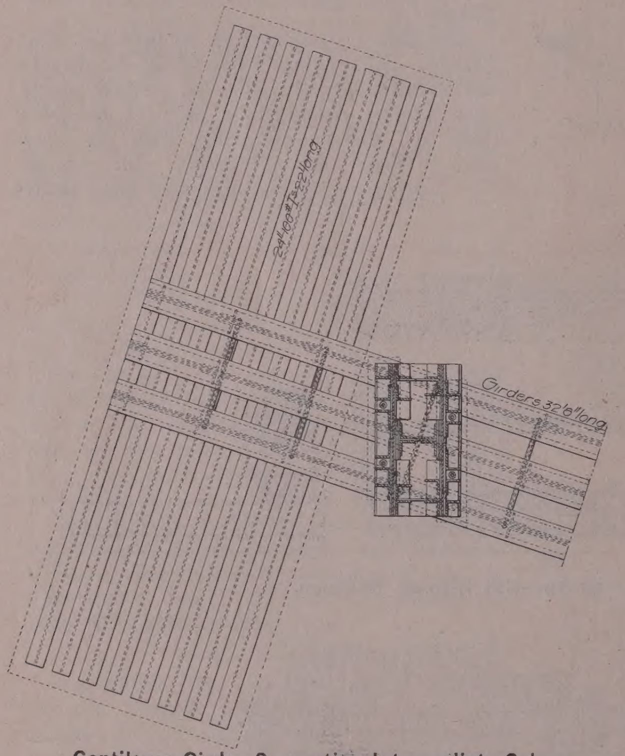
A somewhat similar condition exists at columns 34, 35 and 36, but here the wall column 34 is carried by the cantilever arm, while girder 34, 35 which carries only the two columns and the grillage for column 34, carries no additional load. The boiler loads imposed on the footings of columns 35 and 36 are transmitted directly to them through two single-web 40-in. plate girders outside of the column girders and independent of them which load the grillage beams symmetrically.

The cantilever girders supporting wall columns 44 and 68 are anchored at their inner ends by the interior columns 47 and 65, and like all of the other cantilevers serve also as distributing girders for the grillages of each column. Besides this they carry on their top flanges a short transverse triple-web girder supporting column 46 intermediately between the two cantilevers. Column 46 has a load of 930,000 lb., of which 643,000 lb. is supported at one end of the transverse girder and 287,000 lb. at the other end. The column is located 5 ft. 8 in. from one bearing and 12 ft. 8 in. from the other bearing, and the girder is made with three parts, each of them having one 36 x 11/16-in. web plate, four 6 x 4 x ⅝-in. flange angles, and three 12 x 9/16-in. cover plates on both top and bottom flanges.

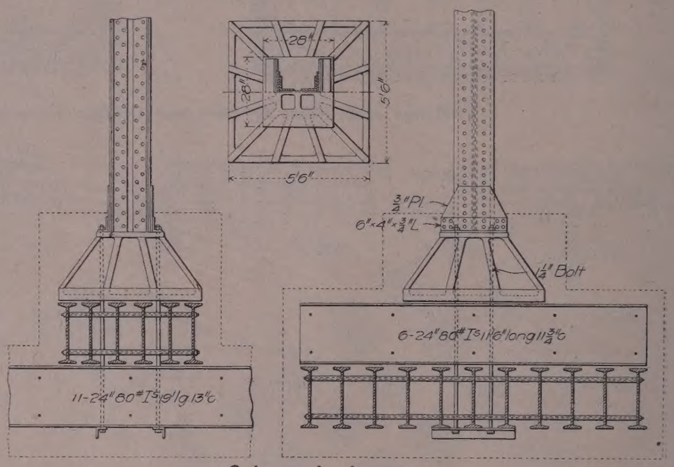
The girders 47, 44 and 65, 68 have the loads, reactions and spacings indicated by the diagram and each of them are composed of three simple-plate girders connected by pairs of horizontal bolts and gas-pipe separators, with the spaces between their webs filled solid with concrete. The bearings on the top flanges of these girders for the column bases and for the transverse girder are made with rust joints, ⅜ in. thick for the cast-steel bases and ½ in thick in the other cases, and all of the flange rivets in the bearing area are countersunk in the flange cover plates.

The location of the corner columns, 66, 69, 70, 71, and 72, is very irregular, and as 67, 69 and 70 are located close to the building line, a somewhat complicated system of cantilever and distributing girders was necessary to transmit their resultant loads concentrically to the grillage areas. This was efficiently accomplished by connecting the anchor end of girder 72-70 with the distributing girder for column 66 and making the latter receive the upward reaction from the anchor arm of girder 67-69, which is thus resisted by column loads 66 and 72. Each of the girders in this group is made with three separate plate girders having the reaction, loads, and dimensions indicated in the diagrams and the materials as shown in the elevations and cross-sections for single girders. The three units for each girder are independent, except as connected by the separators, diaphragms and column bases.

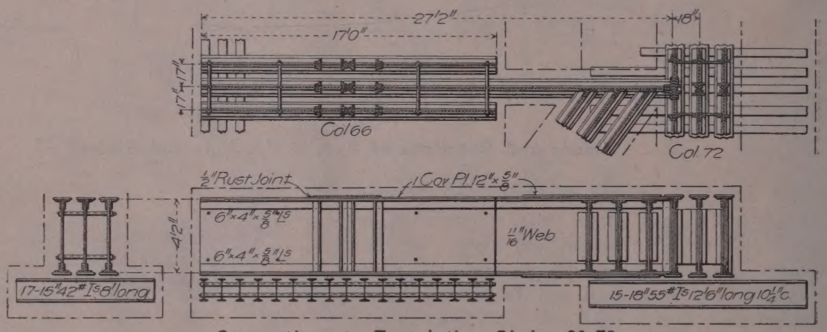




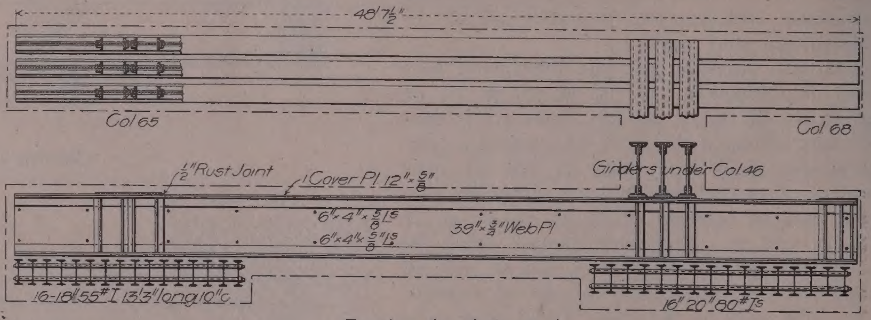
Cantilever Girder Supporting Intermediate Column.



Column Anchorage.



Connections to Foundation Girder 66-72.



Footing for Column 1.

Girders 67-69 and 66-72 are web-connected with vertical bent angles at their oblique intersections and girders 70-72 is reinforced by ¾-in. transverse vertical diaphragms connecting its three webs under column 72, distributing that load and the load transmitted to it on column centers from girder 66-72. In the narrow end of the building the pairs of wall columns 1-85 and 2-86 have special foundation girders calculated to make either column of each pair anchor the other column against the negative reaction, which in these columns only, of the entire building, is developed by the maximum overturning moment of the wind.

The grillages for columns 1 and 85, being permitted to encroach on the street areas, are almost wholly outside of the building line, while the column centers themselves being inside of the same line, are clear of the grillages and are supported by the single distributing girder, which is continuous across both grillages and the intervening space.

The maximum load for columns 1 and 85 is 567,000 lb. dead and 175,000 lb. live. The upward reaction caused by the overturning moment of the wind, based on a 40-lb. wind pressure, is, approximately, 940,000 lb. This necessitated a substantial anchorage of these columns to their foundation girders. At the grillages, under the ends of these girders, these loads are modified to 777,000 lb. dead and 175,000 lb. live, or a total of 952,000 lb., while the uplift from the wind only amounts to 470,000 lb., thus allowing ample margin for stability, and not causing an undue pressure on the natural ground.

The distributing girder is of the same type as those already described, but is deeper, each of its three units being made with a 48 x ¾-in. web, four 6 x 4 x ¾-in. flange angles and three full-length flange cover plates on both top and bottom flanges. The webs are stiffened by pairs of 6 x 4 x ⅝-in. vertical angles under the column flanges, and intermediately 3 or 4 ft. apart. This girder is 32 ft. 8 in. long over all and was shipped and handled in three separate pieces of equal weight.

Columns 1 and 85 are substantially duplicate, made with the regular I-shaped cross-section built up, in the basement, with one 14 x ¾-in. web plate, four 6 x 6 x ¾-in. flange angles, two 16 x ⅞-in., four 16 x ⅞-in., and two 16 x ¾-in. flange cover plates. Instead of being seated, like all the other columns on cast pedestals, they have riveted bases integral with the columns themselves, which are extended across the full width of the compound girder, while pairs of projecting ⅞-in. plates were riveted across the column flanges. These plates have top and bottom horizontal flange angles, making them equivalent to short distributing girders with the webs reinforced, inside and outside, by vertical angles milled to bearing against the flanges.

The outside top and bottom flange angles are pierced with holes for 2¼-in. vertical anchor bolts in pockets between pairs of vertical stiffening angles, and having their upper nuts engaging the top flange angles. The rivets in the plates and angles are proportioned to make the connection transmit the full upward reaction from the column to the anchor bolts, and the latter passing between the webs of the main girder engage transverse reaction girders bearing on the lower flanges of the latter. The column has a ⅞-in. base plate countersunk riveted to a 68 x 42-in. cast-iron sole plate 3 in. thick and 1¼-in. grouted bearing on the top flanges of the main girders. The reaction girders at the lower ends of the anchor rods have rectangular cross-sections made with two 12-in. 40-lb. channels and 12 x ¾-in. full-length top and bottom flange cover plates with countersunk rivets in the bearings with the girders.

The adjacent pair of corner wall columns, 2-84, have maximum loads of 1,256,000 lb., with a 132.25 sq. in. cross-section made up of four 6 x 6 x ¾-in flange angles, one 14 x ¾-in. web plate and 16-in. cover plates of 2¾-in. aggregate thickness. The maximum uplift due to 40-lb. wind pressure is 555,000 lb., and the column is anchored by four 1¼-in. vertical bolts passing through holes in the cast pedestal, and between the webs of the distribution girders and grillage beams, and having nuts bearing on the column base plates and on short horizontal angles across the bottom flanges of the grillage beams.

Progress at End of Second Week's Erection, Phelan Building.

There is no necessity to provide against uplift in any of the other columns, and their cast pedestals are secured to the grillage beams by a simple device which obviates the necessity of holes in the casting. An L-shape cast-iron washer takes bearing with one leg on the top flange of the grillage beam and with the other leg on the edge of the pedestal, thus forming a clamp easily adjustable in any plane to receive the nut on the upper end of the anchor bolt.

The total shipping weight of structural steel was 6,214 tons, and the erection was accomplished in 75 working days.

Mr. W. Curlett was the architect, Mahony Brothers general contractor, and the American Bridge Co., Mr. Paul L. Wolfel consulting engineer, contractor for structural steel.

A 320-FOOT SPAN is reported to have been designed for the reinforced concrete Grafton Bridge, near Auckland, New Zealand. The total length of the bridge will be 910 ft. and the height of the roadway above the deepest part of the gully 147 ft.

The Effect of Tunneling Operations on St. Paul's Cathedral, London.

During the nine years that Mr. Somers Clarke was the "Surveyor of the Fabric," or consulting engineer, of St. Paul's Cathedral in London, he endeavored to discover its stability amid modern conditions by measurements, photography and delicately adjusted testing apparatus. He became convinced that the continued invasion of the subsoil on all sides might speedily endanger the structure on account of certain weaknesses in it. Accordingly, when it was proposed to construct a low-level sewer along the south side of the churchyard, the church officers became alarmed and requested Messrs. Collcutt and Belcher and Sir Aston Webb to act with Mr. Mervyn Macartney, Mr. Clarke's successor, to inquire into the general condition of the building and the effect on it of the proposed tunneling operations. A preliminary report was made a year ago, advising the church authorities to oppose the sewerage work by every means in their power. Acting on this advice the church authorities protested so vigorously that the route of the sewer was changed. The reasons for this action by the advisory board were stated at some length by Mr. Macartney in an address before the Royal Institute of British Architects, from which the following notes have been taken.

The present cathedral is not exactly over the old structure it replaced, for Sir Christopher Wren, the architect, was afraid of unequal settlement of the building under such conditions. His investigations are recorded as follows:

"The Surveyor observed that the foundation of the old church stood upon a layer of very close and hard pot-earth, and concluded that the same ground which had borne so weighty a building might reasonably be trusted again. However, he had the curiosity to search further, and accordingly dug wells in several places, and discovered the hard pot-earth to be on the north side of the Churchyard, about six feet thick and more, but thinner and thinner toward the south, till it was upon the declining of the hill scarce four feet.

"Still he searched lower, and found nothing but dry sand, mixed sometimes unequally but loose, so that it would run through the fingers. He went on till he came to water and sand mixed with periwinkles and other sea-shells; these were about the level of low-water mark. He continued boring till he came to hard beach, and still under that till he came to the natural hard clay which lies under the City, and country and Thames also, far and wide. . . . In the progress of the work of the foundation the Surveyor met with one unexpected difficulty; he began to lay the foundation from the west end, and had proceeded successfully through the dome to the east end, where the brick-earth bottom was yet very good; but as he went on to the northeast corner, which was the last, and when nothing was expected to interrupt, he fell, in prosecuting the design, upon a pit where all the pot-earth had been robbed by the potters of old time. . . . It was no little perplexity to fall into this pit at last; he wanted but six or seven feet to complete the design, and this fell in the very angle northeast, he knowing very well that under the layer of pot-earth there was no other good ground to be found till he came to the low-water mark of the Thames at least forty feet lower. His artificers proposed to him to pile, which he refused. . . . He therefore sank a pit of about eighteen feet square, wharfing up the sand with timber till he came forty feet lower, with water and sea-shells, where there was a firm sea-beach. . . . He bored through the beach till he came to the original clay; being then satisfied, he began from the beach a square peer of solid good masonry, ten feet square, till he came within fifteen feet of the present ground; then he turned a short arch underground to the former foundations which were broken off by the untoward accident of the pit. Thus this northeast coin of the quire stands very firm, and, no doubt, will stand."

In carrying on the work "the greatest care and industry was used, so that by the beginning of April anno 1685 the walls of the quire with the side isles thereto containing one hundred and seventy feet and in breadth one hundred and twenty foot, with the great arched vaults underneath, were finished. As also two stately porticoes North and South opposite to each other and the huge and massive pillars of the Dome (which is one hundred and eight foot in diameter within the walls) brought to the same height, the work being totally wrought of large Portland stone." The topmost stone of the dome was laid in 1710, the date usually taken as marking the completion of the building, though much work was still going on within and without, and much was left undone.

But before this date, in December, 1709, an entry in the Cathedral pay-book records "work done in repairing flaws occasioned by yᵉ pressure, making good such stones as could be left remaining with lead and plaister being the eight Leggs of the Dome and in the inside of the East, W., N., and South cross being above 1,500 foot in perifery." This repairing continues in the two months following. Similar entries are found during the first six months of 1716, where one of the legs of the dome is mentioned as having been repaired with "42 tun of Portland stone," and again in 1722, when repairs to the southeast leg of the dome are specified. From Clutterbuck's "History of Hertfordshire" we learn of Edward Strong that he "also repaired all the blemishes and fractures in the several legs and arches of the Dome, occasioned by the great weight of the said Dome pressing upon the foundations; the earth under the same being of an unequal temper, the loamy part thereof gave more way to the great weights than that which was gravel, so that the southwest quarter of the Dome and the six smaller legs of the other quarter of the Dome, having less superficies, sunk into the thinner part of the loamy ground, an inch in some places, in others two inches, and in other places something more; and the other quarters of the Dome being on the thicker part of the loamy ground and gravel, it did not give so much way to the great weight as the other did, which occasioned the fractures and blemishes in the several arches and legs of the Dome."

From the date of the completion of the shell of the building we have no evidence of any anxiety for the building's safety until 1831. At that time there was much constructing and remaking of sewers in the metropolis, and one was schemed to go round the south side of the church from Ludgate Hill to Cannon Street. Mr. Cockerell, the Cathedral Surveyor, drew the attention of the authorities to the danger, and, together with Messrs. Robert Smirke and George Rennie, drew up the following report:

"We, the undersigned, having by direction of the Dean and Chapter of St. Paul's Cathedral examined and considered the situation in which the Commissioners of the Sewers have begun to construct a sewer on the south side of the Cathedral, and considering that the footings of the walls rest chiefly upon a thin bed of pot-earth, beneath which is a very deep stratum of sand and gravel containing a considerable quantity of water, and that the walls of the south transept have sunk and are fractured, apparently by reason of some partial weakness in this part of the foundations, are of opinion that the security of the fabric will be endangered if the sewer is constructed in the Churchyard. We are likewise of opinion that, however carefully the work may be constructed, it will be impossible to prevent some degree of motion from taking place in the said stratum of sand and gravel either during the construction of the sewer or at a future period in consequence of it; and we therefore earnestly recommend that the Commissioners should be requested to abandon this line for their sewage, and remove it to such a distance as will prevent all risk of injury to the perfect security of the Cathedral."

The result was that the Commissioners of Sewers consented to divert the sewer along Carter Lane, where it was considered it would not in any way affect the foundations of the church. From this time onwards the series of Surveyors' Reports is fairly regular, though there are some years missing. The constant small repairs recommended for the fabric are almost all noted as due to the iron cramps used so largely and insufficiently imbedded in the stone, and frequently this phrase or a similar one occurs. In no case do they suggest any cause for anxiety for the condition of the structure in general. About 1850 some settlement appears to have been noted, but we may judge that it was slight, for in 1853 there were no further movements to record, and the use of a colored cement in stopping the cracks in the masonry so as to facilitate recognition was postponed as of lesser importance than other work about the building, and was not completed until 1856. No further note of alarm as to the Cathedral's safety was sounded until the preparation of the Central London Railway Bill in 1890.

In November of that year Mr. Penrose, the Cathedral Surveyor, reported as follows: "During the late parliamentary session a matter arose which there was reason to apprehend might have seriously endangered the fabric, namely, the proposed Central London Railway, of which the proposed line was in a tunnel running the length of Newgate Street, at a depth of more than seventy feet below the floor of the church. As there is great probability that a tunnel so placed at a depth of more than seventy feet below the floor of the church would drain off the water from the lower strata of the gravel and sand which underlie the foundations of the Cathedral, and so cause them, to some extent, to collapse, there would be great risk of serious injury to the structure. This scheme passed a Committee of the House of Commons, but was thrown out by the Committee of the other House, not indeed without cost to the Dean and Chapter, but it appears to be a great danger averted." This brings the subject down to comparatively recent history.

The main points of weakness in the Cathedral—the parts, that is to say, which have shown, and on the slightest disturbance will show again, signs of settlement and movement—are the dome, the south transept, and the western towers and portico. The Dome was repaired during the building, when the southeast pier sank owing to the inequality of the subsoil. In 1878 the dome was measured, and it was found that while there are signs of a very measurable amount of subsidence and disturbance of level having taken place in the structure, yet that a very large part of this had already occurred during the progress of the work, and that some of the courses of stone-work, especially those immediately above the dome cornice, are thinner considerably in one direction, so as to compensate for what had then occurred, and to bring the upper part of the structure again level. This shows that such movements as have more recently occurred are very much less in amount than they otherwise might be supposed to be. It was found in 1884 that this compensation occurs in the cupola itself.

The settlement of the dome shows that, in spite of the care with which Wren spread the weight, the center of the great mass has sunk and is now severed from the surrounding masses.

The dome is carried on eight great piers about thirty feet long; these at the crypt are connected with the bastion-like masses at the angles of transepts with nave and choir by long barrel vaults: these are in every case cracked through. These bastions, were they solid, might easily have contributed to the sinking of the dome, but in fact they are admirably contrived for their purpose as counterweights, and being much hollowed for staircases, vestries, and the like.

The weight of the superstructure rests much more on the inner ends of these eight piers than on their outer ends, in spite of Wren's devices to distribute the weight, and the sinking of these piers has set up movements overhead. Moreover, these great piers have not sunk equally, those on the south side connecting with the south transept being lower than the others; and of these the westernmost has descended bodily over six inches.

When the west window of the south transept was repaired in 1891 Mr. Penrose referred to it as having been much dislocated by a settlement of old standing, of which happily there seems to have been no recent recurrence. The south transept has suffered, in addition to the dislocation of the parts abutting on the dome, by the tendency of the south front of it to move outwards.

The portico was much repaired in 1890, the stonework having suffered to a very great degree from the oxidization of the iron cramps; among other things the whole of the frieze was taken down piece by piece and replaced and in many places renewed.

The walls of the southern façade have moved outwards, and have sunk slightly to the east and west: this showed itself in the south window arch and in the upper part of the transept. In 1897 it was noted that the window arch was resting on and had actually bent the iron stanchions which were intended merely to stiffen the lead glazing, and that the glazing itself had been crumpled. To remedy this a steel frame for the window was inserted at the time when the new glass was put in, a similar precaution being adopted in the north transept, where the same had happened, though not so badly. Early in the last century strong iron rods had been inserted longitudinally below the window in the south transept, as well as in the direction of the dome, and these it was found necessary to augment in 1898, when additional tie-rods were inserted above the window and at the roof level, and anchored back into the masonry as near the great piers of the dome as could be contrived, as the wall then still showed a tendency to advance southward. But Mr. Clarke, who was satisfied as to the efficacy of these rods for all ordinary purposes, took care to add, in 1901, that the system of tie-rods was not undertaken at a time when the fabric was threatened with the very near approach of the proposed electric railways, and could not be considered as sufficient against so great a danger.

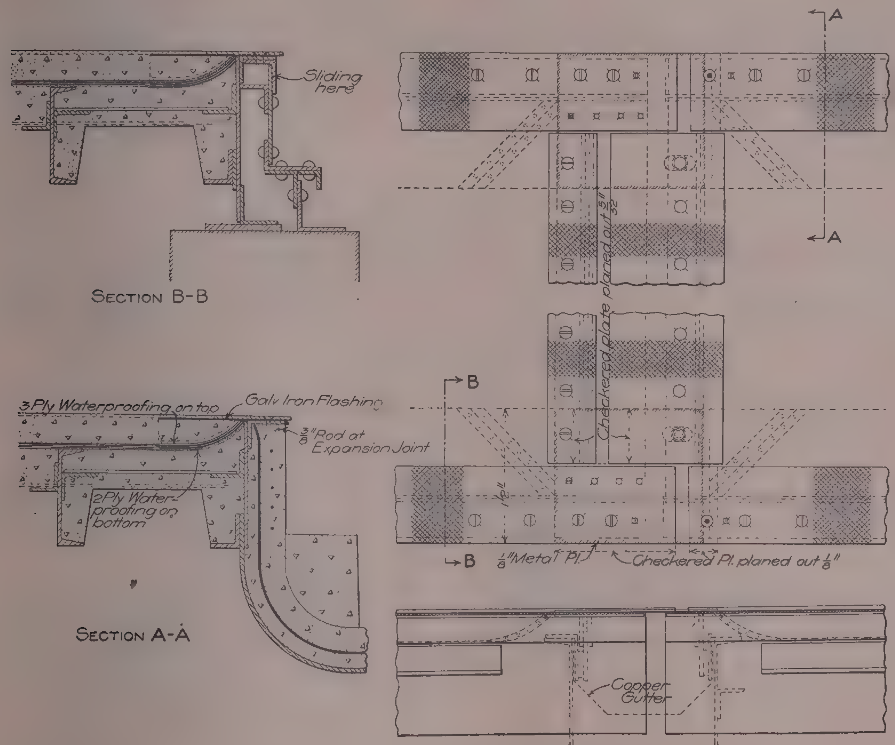
Coming to the west front we find two tendencies at work, the one arising from the other: the two towers are out of the perpendicular, the one to the north and the other to the south; and the portico, which has been said to be the only flimsy piece of construction in the Cathedral, has followed the direction of the towers, and, in addition, has moved westwards. In August, 1901, the southwest tower was plumbed to a height of some 113 ft., and a deviation was noted which when worked out proves that the top hangs over some inches southwest, while the other tower inclines, though to a less degree, to the northwest. The movement of the south tower has affected that part of the building east of it, and in the library, over the southwest chapel, the indications of the movement are very clearly seen. These inclinations are sufficient in themselves to jeopardise the safety of the two wide arches of the portico between the towers. The towers actually form the abutment of these arched ceilings, which have a span of 48 ft., while they do not rise 10 ft.

The portico consists of two stories, and the front is composed of two series of coupled columns, and is not in itself a very stable piece of construction. Instead of the spaces between them being bridged by single pieces of stone, concealed arches are made use of: at the north and south ends these arches are without any solid abutment, and yet on them rests the heavy mass of the pediment. Then the two ranges of columns each support a cornice which projects westwards, with no similar projection to the east to counterbalance it. Above the upper cornice the cornice of the pediment and the sculpture of the tympanum also overhang. Thus there is a height of about 112 ft., and the shafts of the columns supporting it 4 ft. at their thickest, with considerable voids between them.

Sir Christopher Wren was probably wise in constructing this portico as he did. The size of the stones used and the slight dependence on the west front of the church would rather increase than lessen its durability; for, being comparatively independent of the great mass behind it, it could adapt itself to any possible movement, whereas, had it been rigidly and thoroughly secured to it, it would have been liable to any of its accidents. However, after very considerable repair and much renewal, the portico has been restored to its original state—allowing of course for the increase in its span—and, assuming that existing conditions can be maintained, may be said to be safe. But we have learned the secret of its weakness, and we see how dependent it is on the western towers, and how they in turn stand or fall with the character of the supporting ground.

Waterproofing Ballasted Bridge Floors at Schenectady, N. Y.

The subject of properly and thoroughly waterproofing railroad bridges crossing city streets is an important one, and recent practice of one sort is illustrated by the track elevation work on the main line of the New York Central & Hudson River R. R. in Schenectady, where the character of the topography indicated that the proper method for eliminating the crossings was by elevating the tracks. This necessitated building bridges over the Delaware & Hudson R. R., Edison Ave., State St., Liberty St., Union St., Green St. and Front St. on the main line, and on the Troy & Schenectady R. R. at Union St., Center St., Fonda St., Nott St. and Peek St. Between State and Liberty Sts. the tracks for the most part are carried on a steel viaduct in order to accommodate the station, a considerable portion of which is placed under this viaduct. It was considered very important that there should be no leaks or drips from the overhead bridges on the streets and especially that there should be no leaks on the viaduct over the station, and, therefore, particular care was exercised throughout the work in order to obtain this result. All of the bridge work is of plate girder construction, with floors of either the standard rectangular trough construction or of an I-beam type having 7/16-in. continuous sheets of flat deck plates. In both cases the broken-stone ballast is continuous across the bridges, which carry from three to nine tracks. During the open seasons of the last two years about 91,000 sq. ft. of floors of this sort have been waterproofed, the materials and processes used varying somewhat on the different structures.

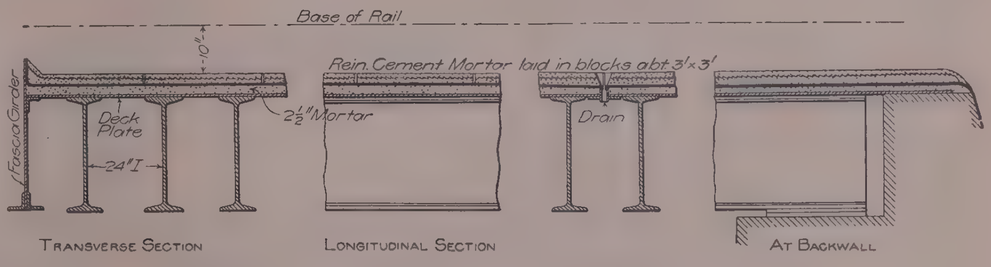

Sliding here
SECTION B-B
3 Ply Waterproofing on top
Galv. Iron Flashing
3/8" Rod at Expansion Joint
2 Ply Waterproofing on bottom
SECTION A-A
A
A
B
B
Checkered plate planed out 1/8"
1/8" Metal Pl.
Checkered Pl. planed out 1/8"
Copper Gutter

Details of Expansion Joint in Floor.

The Front St. and Green St. bridges are through plate-girder structures with solid floors of transverse troughs about 16 in. wide made with 15-in. channels and several top and bottom plates, web-connected at their ends to the main girders Three thicknesses of burlap and hot asphalt were successively applied directly to the clean dry-painted surfaces of the troughs, making a continuous covering for the bottom, side and top and being flashed up to the corresponding height on the vertical faces of the longitudinal girder webs. Rounded fillets of mortar were placed in the right angles between the bottoms of the troughs and the vertical girder webs to support the burlap, but elsewhere it was pressed close to the surface of the steel plates, angles and rivet heads.

The asphalt was covered in the bottoms of the troughs with a 2-in. layer of cement mortar sloped to drainage holes with small vertical nipples screwed through the bottom plates of the troughs. The mortar was covered with a single course of vitrified paving bricks laid flat with asphalt joints. Holes were chiselled through the bricks to match the drainage nipples.

The joints between the transverse fascia girders and the back walls were made with a horizontal steel apron plate riveted to the girder and resting on the upper surface of the wall, which served to support the waterproofing laid directly on the masonry, flashed up under the top flange of the girder, and covered with a thin layer of mortar reinforced with expanded metal, as indicated in the detailed sketch.



Beam Floor Waterproofing with Reinforced Concrete Protection.

Some time after the first section of waterproofing was completed a thorough investigation showed that there were leaks in it and that the burlap, although supposed to be thoroughly saturated with hot asphalt, was very wet in places. Some modifications were therefore introduced in the similar State St. and Union St. bridge floors, where the bottoms of the troughs were first covered with a 2-in. layer of cement mortar sloped to drainage holes in which conical, flanged cast-iron nipples were screwed, providing well protected openings.

As the previous experience demonstrated that the most thorough mopping with hot asphalt failed to saturate the burlap, the latter was first efficiently saturated by dipping it in hot asphalt cut with coal-tar naphtha, after which it was allowed to dry before using. It was laid on top of the mortar, continuous over the tops and sides of the trough, mopped with hot asphalt, and covered as before with vitrified brick in the bottom of the trough. The pitch of about 3/16 in. per foot and the flashing of the burlap over the top flanges of the cast-iron nipples prevented leakage to the concrete, but it was found impossible to prevent the development of slight leaks in the connections between the ends of the trough and the girder webs.

The Fonda St. bridge has the same trough floor, but the waterproofing was modified by replacing the course of vitrified bricks on top of it by 4 in. of cement mortar reinforced with expanded metal and having holes cored in it to register with the drainage nipples. An effort was made to turn the burlap down inside the nipples, but this, of course, was difficult to accomplish and better results were obtained with the cast-iron conical nipples subsequently used.

The Center St. and Edison Ave. bridges have I-beam floors with flat deck plates covered with 2½ in. of 1:4 cement mortar pitched to drainage nipples screwed through the deck plate, where the mortar was reduced to its minimum thickness of 1½ in. The burlap was applied to the surface of the mortar and flashed up on the vertical webs of the girders as already described, and was covered by a protecting course of 3 x 3-ft. concrete slabs 1½ in. thick reinforced with expanded metal and having conical holes cored through them to register with the drainage nipples. The slabs were made 1 part cement to 3 parts sand.

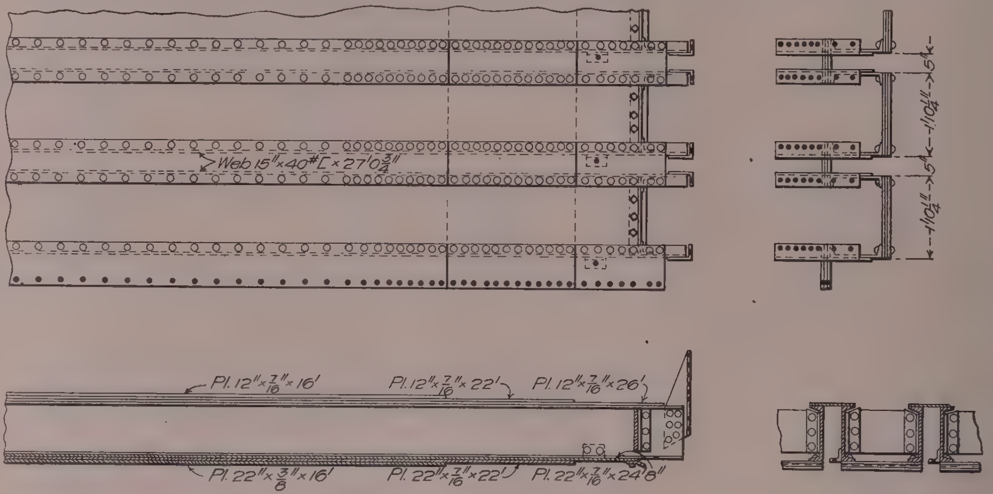
The waterproofing of these bridges appears to be very efficient, and although it has been subjected to severe conditions, no leaks have been observed, although under similar conditions leaks did develop at the girder webs in the trough floor spans.

The most important waterproofing was that of the station viaducts 450 ft. long and 62 ft. wide, exclusive of a wide extension at one end over Liberty St. and a platform over the waiting room, which increased the total area to 40,000 sq. ft. The floor was connected with the retaining wall and with the building walls on the side and the entire space below it is to be occupied by a portion of the waiting room, baggage and express rooms and other portions of the station and by rented stores, thus making it imperative that it should be absolutely protected from any drip or moisture. Tracks 1 and 2 are carried on two-column bents with transverse girders cantilevering at both ends to carry part of the platforms, which have transverse I-beams framed at this point to the fascia girder and carried at the opposite ends on the retaining wall or on another row of columns, as indicated in the general cross-section. The track floor is made with longitudinal I-beams and a continuous top flange cover plate and the platform floors are made with reinforced concrete slabs containing sets of prismatic vault lights.

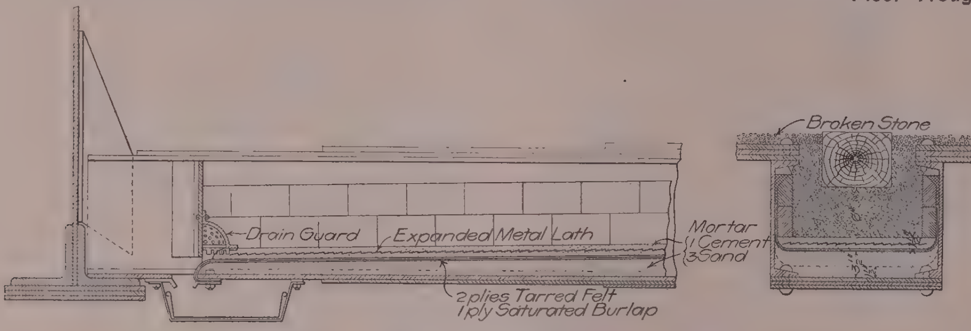
The regular water-proofing corresponds substantially to that of the similar floors in the Center St. and Edison Ave. bridges, except that it is made with two plies of tarred felt mopped with hot asphalt and an upper ply of burlap saturated before laying, and mopped with hot asphalt. All plates and angles in the steel work joints were made with beveled edges calked after riveting and proved to be absolutely tight by testing with water 10 in. deep.

Where the platform and track floors join the deck plates of the latter are curved upward to an easy radius and are riveted to the lower flanges of the fascia girders and the mortar course and waterproofing are carried on them and beyond, vertically upward to the top flanges of the fascia girders, the burlap being covered with a layer of hot asphalt and a single course of vitrified brick laid flat with sand and asphalt joints. The upper surface of the brick is about 10 in. below the base of the rail and the bricks follow the curve to the vertical tangent, above which they are replaced by concrete slabs with expanded metal reinforcement extending to the top flanges of the fascia girders and anchored every 3 ft. by ⅜-in. vertical rods passing through the top flanges of the girders. On the station side of the girder the expanded metal was replaced by three lines of ⅜-in. horizontal rods wired to ⅜-in. vertical rods.

The three expansion joints reach across the full width of the viaduct on the center lines of the transverse bents and are of rather complicated construction on account of the different heights of the surfaces and the motion to be provided for, especially at the intersections with the fascia girders. The general arrangement of the steelwork is shown by the vertical sectional elevation through the end of the transverse girder, taken parallel with the axis of the bridge. The fixed ends of the longitudinal beams are riveted to one side of the girder web and the sliding ends of the adjacent beams are supported on horizontal shelf angles riveted to the opposite side of the girder web.



Floor Trough Construction.



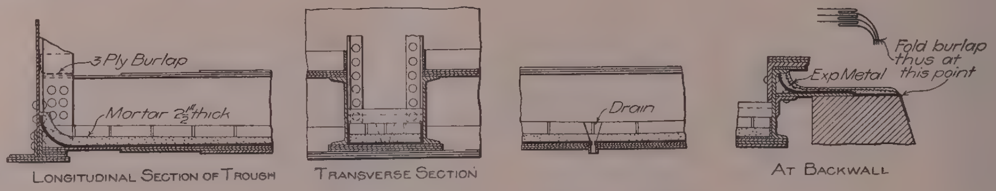
Latest Type of Waterproofing for Trough Floor.

An inverted rectangular trough of solid plates forms part of the top flange of the girder and has the lower edges of its vertical side plates riveted to the fixed and sliding ends of the floor plates, thus providing a continuous hood over the top of the girder with tight riveted connections at the end through the curved floor plates which connect the platform and track floors.

Above the hood the vertical longitudinal side plates are connected in the usual manner by cover splice plates with slotted holes. The waterproofing is carried up under the top flanges of both sides of the fascia girder as already described and as shown in one of the detail sketches.

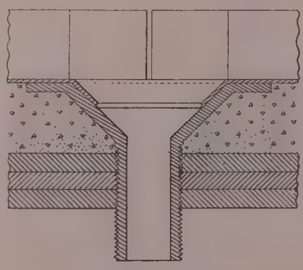
The expansion joint in the platform floor is made by a checkered steel plate sliding on a transverse apron angle in the usual manner, and any leakage which passes through it is intercepted by the transverse trough of 24-oz. copper with its sides carried up between double clamping angles and flashed under the regular floor waterproofing beyond the two fascia girders. In the track floor the regular waterproofing is carried over the riveted hood which encloses the top flange of the transverse girder exactly as it is carried over the tops of the rectangular trough in the floors of the State and Union Sts. bridges.

The bases of the canopy columns are web-riveted between transverse channels and are filled, above the floor plates, with about 8 in. of concrete. On the outer surface there is a concrete fillet in the angle with the floor plates and the waterproofing is flashed up around them substantially as it is carried up against the vertical surfaces of the girder webs. The construction of the longitudinal joints between the viaduct floor and masonry retaining wall required great care to make them water-tight and provide for the expansion and contraction to temperature changes.

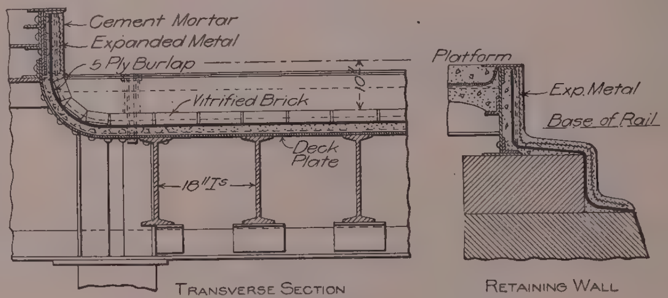


Longitudinal Section of Trough
Transverse Section
At Backwall

Waterproofing with Brick Protection.



Drainage Nipple.



Transverse Section
Retaining Wall

Waterproofing at Platform and Side Wall.

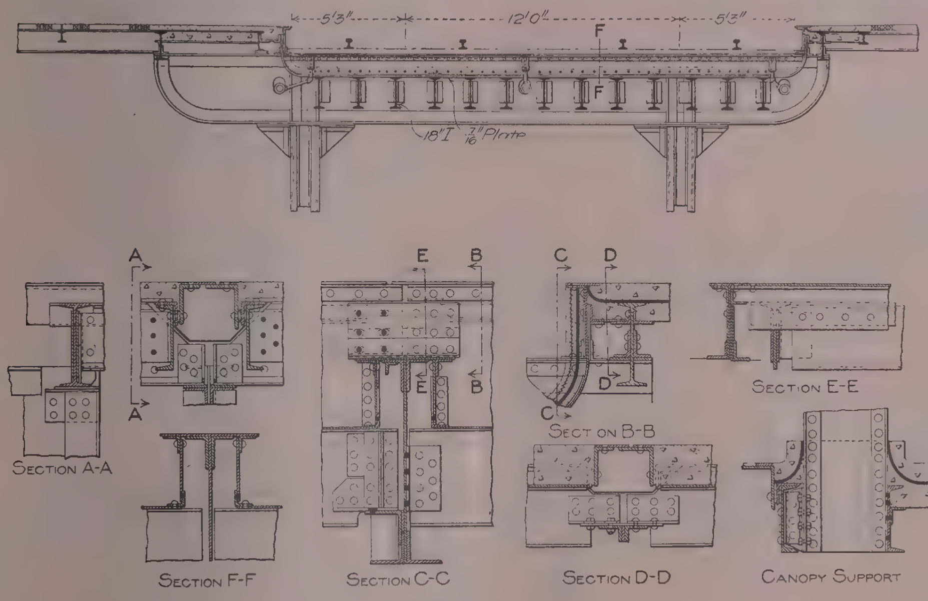
One longitudinal edge of the platform floor is carried on a continuous wall girder, which also serves as a fascia girder and retains the floor concrete. This girder has continuous longitudinal shelf angles riveted to the inner face of the web to sustain the concrete and is seated with its lower flange bearing on a plain wall plate upon which it is free to slide back and forth. The upper flange is made with two angles countersunk-riveted together to form a channel-shaped section of the outer face of the web, interlocking with the vertical web and the horizontal edge of the flange angle of the fascia girder, which has a peculiar offset cross-section, as shown in the detail sketch, adapted to overhang the other wall girder and retain the concrete of the floor. This arrangement provides a sliding contact without transverse clearance between the parallel girders, and the waterproofing is so arranged as to prevent leakage over the continuous joints.

The platform waterproofing at this point consists of five plies of fabric on a bed of concrete mortar laid on the surface of the concrete floor slab and covered by 3 in. of protective concrete. In the edge of the platform a continuous sheet of No. 24 painted galvanized iron flashing about 12 in. wide was inserted between the second and third layers of waterproofing fabric and curved upward with them to the top of the fascia girders and carried over the flange of the latter, where it is secured between it and a checkered steel apron plate fastened with ⅞-in. countersunk tap bolts.

On the other edge of the platform, where its floor is joined to the track floor, both move together and the fascia girder is an integral part of both. Here the waterproofing fabric is not continuous around the upper flange, but terminates there on the track side, where it is protected by a reinforced concrete slab. On the platform side a continuous galvanized iron flashing strip is inserted between the layers of the waterproofing fabric, as already described, and curved up to the top of the girder and carried across the flange between it and the checkered steel plate in the same manner as for the longitudinal sliding joints. Where the transverse and longitudinal sliding joints intersect, the curved galvanized flashing plate has a soldered miter joint, reinforced with

¼-in. rivets, as indicated in the plan, thus making the flashing continuous around the angle. As this joint was not made until after the structural-steel work had been erected, no provision existed for the flashing under the checker plates, and the longitudinal ones were removed and ⅛ in. was planed off from the under side at the transverse joint opening just beyond the opening between the apron pieces, to clear the continuous flashing around the angle which crosses unsupported the 3-in. opening underneath the checker plate and is exposed only between the adjacent edges of the checker plate, where it is firmly supported on the apron angle.

When the first course of cement mortar was at least 24 hours old and thoroughly dry and when the steel work was perfectly dry, clean and painted with two coats of asphalt paint, both steel and mortar surfaces were mopped with asphalt at 350° Fahr., heated in a 150-gal. kettle and delivered as required in buckets. Saturated felt was immediately rolled over the hot asphalt and smoothly pressed against it to secure complete adhesion and all of its joints were lapped at least 2 in. and staggered. The second layer of felt and the burlap were similarly applied. The asphalt was heated to a maximum of 350° and was considered satisfactory when it produced a bluish vapor and did not adhere to a pine stick dipped in it.



Double-Track Floor Details.

After the burlap layer was placed it was thoroughly mopped with hot asphalt in sufficient quantity to conceal it and fill all cracks and blow holes. The porosity of the hard burned first-class brick was limited by the requirement that their weight should not be increased more than 10 per cent. by 7 hours' immersion in water. They were heated in stack so as to be thoroughly dry when used and were laid flat in hot asphalt with ¼-in. open joints afterward filled to within ¼ in. of the top with dry sand and flushed with hot asphalt.

The burlap weighed, before saturation, about 7 oz. per yard 40 in. wide and was selected for strength. Where the waterproofing is protected with cement mortar the latter is laid in two courses with a reinforcement of No. 27 gage expanded metal between them. The second course is laid immediately after the first, so as to bond with it and form a single slab, which is divided into areas of about 9 sq. ft. No mortar or concrete was applied to any asphaltic surface until the latter was entirely cold and no ballast was laid until the asphalt joints in the brick protection were hardened or until the concrete protection was at least 24 hours old, and traffic was not admitted until the mortar or concrete protection course was at least 7 days old. The requirements specified for the asphalt were as follows:

"1. The asphalt shall be pure refined, high-grade asphalt, free from coal tar, turpentine or any of their products, and shall contain not less than 97 per cent. of bitumen soluble in carbon-bisulphide, and of the bitumen thus soluble in carbon-bisulphide not less than 60 per cent. shall be soluble in 88° naphtha, air temperature. 2. It shall not volatilize more than 5 per cent. under a temperature of 350° Fahr. in 7 hr. 3. It must not be affected by a 25 per cent. solution of sulphuric acid acting upon it at an ordinary room temperature for 7 hr. 4. It shall not flow under 212° Fahr. and shall not become brittle at 15° Fahr. below zero when spread in a layer ⅛ in. thick on thin glass."

After the construction and waterproofing of the floors above described, it became evident that the tamping of the ballast and other track work is certain sooner or later to injure the waterproofing on the top and upper edges of the trough, and for the later Peek and Nott St. bridges a protection was at first devised which consists of trough-shaped caps of No. 12 galvanized iron riveted together and placed with their flanges down over the top plates of the floor, thus entirely covering the upper parts of the waterproofing. Difficulty was experienced in designing them to fit around the gusset-plate kneebraces between the tops of the floor troughs and the webs of the main girders, and at this point it was planned to replace them by short sections of horizontal angles riveted to the floor trough. As the additional expense of these caps was found to be considerable on account of the great number required by the close spacing of the troughs, it was decided to omit them on the Nott and Peek St. bridges, but they will be applied to the cross beams of the station viaduct, which are spaced 16 ft. center to center as a rule, and where the importance of waterproofing is much greater. In this location caps of No. 14 metal, not galvanized but painted, were finally adopted.

The Nott and Peek St. bridges illustrate the latest practice in the design and waterproofing of trough bridges, which is shown in the cross-section of a floor trough where the bottom only is first covered with 1:3 cement mortar 3½ in. thick at the center and pitched to a thickness of 1½ in. at the ends. The upper surface of this mortar and the vertical faces of the trough receive one coat of Sarco waterproofing paint. Two plies of tarred felt, flashed up a few inches on the vertical webs of the trough, are then mopped in place with hot Sarco compound No. 6 and covered by one ply of burlap reaching up a little higher on the sides of the trough web and saturated before laying in the hot compound. The bottom of the trough is covered with 1½ in. of 1:3 cement mortar laid on top of the burlap and reinforced with one sheet of expanded metal lath. The upper surface of the mortar is troweled smooth and flat, and on it are placed vitrified brick on edge protecting the vertical sides of the trough. The upper bricks clear the trough flanges of about 1 ft. and have their inner corners beveled, forming pockets which are filled with hot compound and closed with Portland cement mortar pointing neatly calked in place. The top plates of the trough and the edges of their upper flanges are covered with Sarco compound mopped on top and the troughs are filled with ballast, the track ties placed and rails laid as usual. In other bridges the waterproofing has been done with Neufchatel asphalt.

No attempt is made to connect the trough waterproofing with the webs of the main girders. It is, on the contrary, limited by vertical transverse diaphragm plates riveted in the trough a few inches clear of the bottom flanges of the girders, as indicated in the longitudinal section of the trough. An opening is left in the bottom of the trough close to the diaphragm and protected by a perforated convex drain guard which excludes the ballast and permits the water to flow under the diaphragm and over the end of the waterproofing to a longitudinal gutter bolted to the underside of the floor close to the girder flange.

The waterproofing is carried over the end of the trough floor and secured underneath it by continuous bent clamp plates with a projecting lip which prevents the water following back on the plate. The gutter receives all drainage from the girder flange, is conveniently located for inspection and repairs and can readily be cleaned or inspected throughout its entire length. It is believed that this arrangement provides for most of the difficulties encountered with the previous types of waterproofing, and as it has given good satisfaction in results and cost of installation it is understood that it will be adopted on the New York Central & Hudson River R. R. where such construction is desired.

All the work here described, except the station viaduct platform work, was executed by the company's forces, and was designed and supervised by the Engineering Department, Mr. C. J. Palmer, principal assistant engineer; Mr. C. P. Marsh, former bridge engineer; Mr. A. W. Carpenter, engineer of structures. The platforms of the station viaduct were executed by contract, after the design and under the supervision of Messrs. Reed & Stem, architects. Mr. George W. Kittredge, chief engineer of the company, had charge of the entire work.

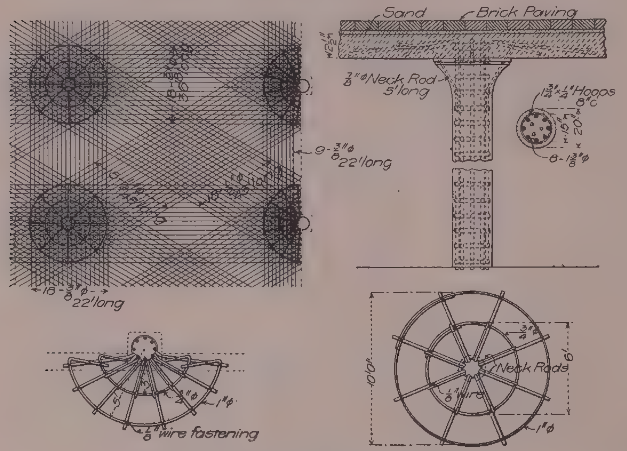
A REVERSIBLE VARIABLE-SPEED STEAM TURBINE invented by Mr. G. Belluzzo has recently been tested. When running as a two-stage reaction turbine at 3,000 r.p.m., it developed 80 h.p. The expansion takes place entirely in the guide blades and the rotor blades of the six blade-wheels. At 2,000 r.p.m. the turbine develops 40 h.p., the steam entering through a different nozzle, in which it is almost completely expanded before reaching the blades. At this speed the turbine works as a three-stage impulse motor, the above-mentioned two stages and a third stage consisting of four blade-wheels. This last stage is also used for reversing, for which purpose the blades have a double curvature, the inner sides being used for forward running at 2,000 r.p.m. and the outer sides for backward running. There is a third admission nozzle at the exhaust end of the turbine in which the steam is almost completely expanded before reaching the blade.

The New Freight Depot of the Wisconsin Central Ry. at Minneapolis.

By S. G. Harwood, Minneapolis.

There has lately been completed in Minneapolis, Minn., a reinforced concrete freight depot for the Wisconsin Central Railway, which takes the place of a steel and brick structure, destroyed by fire over a year ago. The building is a short distance west of the Mississippi River and approximately parallel to it, facing Hennepin Avenue on Bridge Square. It has three stories and a basement and measures 418 ft. long and 76 ft. wide, the basement having an additional width of 34 ft. to accommodate the driveway.

The building is divided transversely into three bays, running the length of the building, the one on the river side being of variable width and following the curvature of the railroad property line on that side, the second bay 24 ft. 10 in. in width and the third bay 24 ft. 2 in. Alongside the last bay there are driveways both at the street and basement levels, the width being about 30 ft. 5½ in. The driveway at street level is carried over the one beneath on a concrete floor and as the drive is enclosed on all sides, it virtually forms a one-story bay entirely beneath street level, running parallel to the length of the building.



Reinforcement of Mushroom System.

Freight is brought into the building directly by the cars of the railroad company on tracks in the two bays on the side toward the river. They are unloaded onto a platform, occupying the entire width of the third bay and raised to the elevation of the car floor. Delivery of freight directly from this platform is possible to trucks using the covered driveway above described, but most of it will be raised to the main delivery floor, at street level, and to the two storage floors above it. The rapid handling of freight from the platform in the basement to the upper floors is assured by an equipment of one 10-ton and four 5-ton electric elevators. Ten doors are provided for the delivery of freight and before each of them is a scale, thus saving extra cartage within the freight depot itself to have the freight weighed. The interior of the building is not divided by partition walls, but the section divisions assigned to various merchants are designated by appropriate signs. The building is of fireproof construction throughout and the doors both to the outside and those dividing the track bays from the platform in the basement, are sheet iron drop curtains. Offices are provided for the superintendent and the clerical force in the front part of the building on the street floor.

The reinforced concrete skeleton of the building, which is enclosed by brick outside walls, is constructed entirely on the Turner system, designed by Mr. C. A. P. Turner, Minneapolis, Minn. In the building itself the floor system consists of slabs carried on the conventional beam and girder system, but the upper driveway at street level is a concrete slab reinforced on the mushroom system.

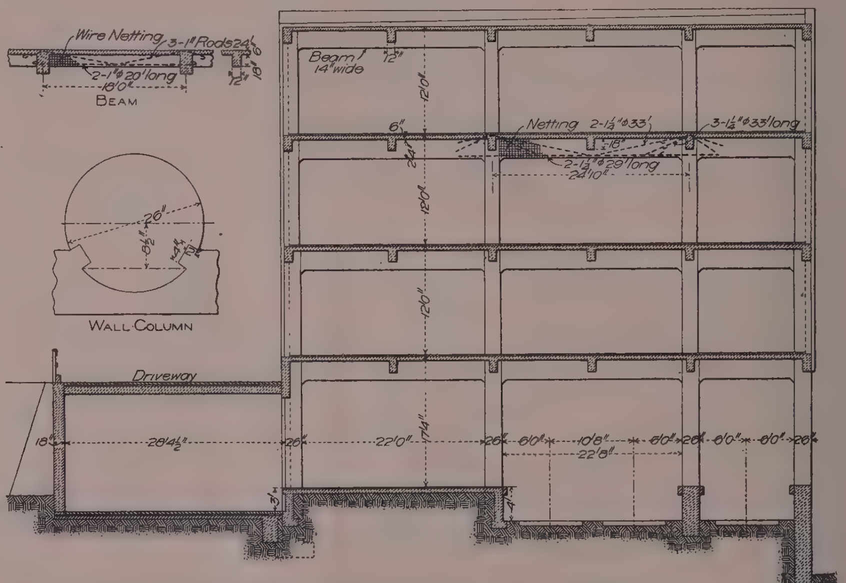
The columns supporting the driveway in the mushroom system are 15 ft. 1 in. high from the floor line to the bottom side of the roof slab and are reinforced with eight 1⅜-in. round rods surrounded by 1¾ x ¼-in. hoops on 8-in. centers. The columns are 20 in. in diameter and the hoops 15 in. on the inside, thus leaving a thickness of 2¼ in. of concrete outside the steel. These heavy reinforcing rods run up to within a few inches of the top of the floor slab and are then bent over and outward on radial lines, extending a little over 5 ft. from the center of the column. These projecting rods are bound together and strengthened by two ties laid in concentric circles, one a ¾-in. rod 3 ft. from the center of the column and the other a 1-in. rod 5 ft. from the center. These are tied to the radial rods by means of ⅛-in. wire. In addition to the main reinforcing rods, which are bent over as described, eight additional rods, ⅞ in. in diameter and 5 ft. long, called neck rods, run down into the columns, are bent diagonally so as to resemble a bracket and terminate in a horizontal portion 19 in. long, which loops over the smaller of the concentric circular rods above referred to. These rods are so placed as to generate an inverted cone-shaped figure, which is neatly rounded out into a smooth curve in the concrete work. In the wall and corner columns it is not possible, of course, to bend the rods over in all directions and they are consequently confined either in a semi-circle or in a quarter circle, the tie rods naturally being also limited to semi- and quarter-segments.

The floor reinforcement which carries the loads to these columns consists of ⅜ and ½-in. rods spaced on about 6-in. centers and running not only parallel to and at right angles with the lines of columns, but also diagonally between columns at the opposite corners of rectangles. The floor slab is 11½ in. thick and carries a brick pavement bedded in sand. Both the driveway at street level and the one in the basement are depressed so that the wagon beds come at the level of the shipping floor in the first case and of the platform in the second.

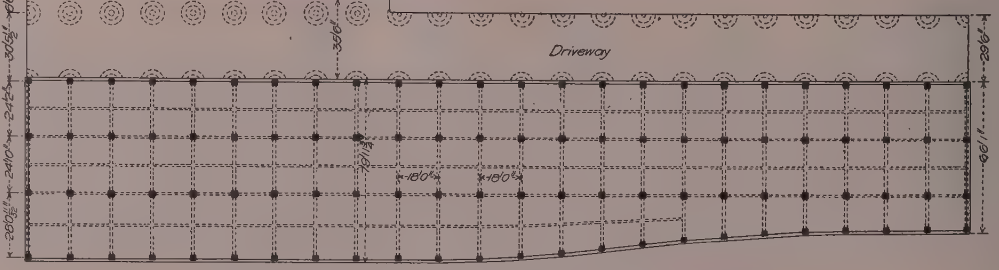
In the building proper all columns in the basement are 26 in. square. The columns on the upper floors are all round. The reinforcement of all of the columns in any given story is the same, the longitudinal rods being eight in number in all cases and varying according to the story in which they are used from 1¼-in. to ¾-in. round rods. The reinforcement of all the columns is surrounded by hoops, outside of which is at least 1 in. of concrete. In the basement the hoops, which are all welded, are made of 2 x ¼-in. bar, while for the other stories, 1¾ x ¼-in. bar is used. The minimum spacing of these hoops in the inside columns of the basement is 5 in., while for the intermediate columns of the other stories the spacing is 7 in., and for all of the wall columns 8 in. All round columns on the wall line have slots running vertically, in which the inside layer of brick is laid, as shown in one of the diagrams.

The maximum girder span is 22 ft. 8 in. and the section used is 18 in. wide and 2 ft. 4 in. deep beneath the floor slab, which, being 6 in. thick, makes a total depth of 2 ft. 10 in. from the top of the floor slab to the bottom of the girder. The girder reinforcement, except under the roof, consists of seven 1¼-in. round rods, two of which run horizontally through the full length of the base, three turn up diagonally at the quarter points and the remaining two run diagonally upward from the center of the beams to a point a few inches below the top of the floor slab at the center line of the columns.

All the rods, and it may be remarked, those in the beams, too, run over into the girders of the adjoining spans from 30 to 36 in., being bent downward sharply and having a hook at the end. The reinforcement of the beams is of a similar order excepting that the rods, which in the girders turn up at the quarter points, are omitted. All of the beams are wrapped before concreting with 7-11 wire netting of 4 x 6-in. mesh. The sub-



Section and Reinforcement of Wisconsin Central Freight Depot.



Plan of Wisconsin Central Freight Depot, Minneapolis.

beams have a depth of 18 in. below the bottom of the floor slabs, are 12 in. wide and have a span of 18 ft., this being the longitudinal spacing of the columns.

The floor and roof slabs are 6 in. thick, reinforced with ⅜-in. rods in both directions, those immediately on either side of the columns being on 10-in. centers and those across the center of the span on 6-in. centers.

The round columns were built with sheet iron forms, clasped with bars of wrought iron at the horizontal edges and bolted with stove bolts at the vertical edges. These forms were found economical and had a long life when given proper care. They require but little time to erect and to remove. In the bottom sheet of each column a slide is placed so that dust and débris may be removed from the box before casting. The concrete for the floors was poured on corrugated sheets of iron supported by 2-in. planks laid in both directions and carried by uprights from the floor below.

The storing of materials and mixing and distributing of the concrete was handled in an interesting and economical manner. Trains bearing the materials were run in on the tracks in the basement, and parallel to these a narrow-gauge track was placed. The sand and cement were loaded on to small dump cars which were pushed to the elevator well, where the materials were raised to bins by a scoop. The cement was left in the sack and hoisted in a sling to the storage space above. The mixer was placed in the basement about 6 ft. above the floor level and the materials were supplied to it from the bins through three chutes. The concrete was deposited in a bucket elevator, which raised it to the desired floor. Concrete was delivered to the point where needed by means of small cars on a track. A single track was used for distribution, but the installation of a turntable allowed the use of two cars. The whole pouring gang consisted of six laborers and a foreman. Two men were required to handle each car and two men with shovels did the spreading. The brick for the outer walls was delivered by freight cars in the basement, unloaded into wheel-barrows, lifted by a contractors' elevator and wheeled to the bricklayers, who laid them from the inside. No outside scaffolding was used, projecting horses being used for the layers otherwise inaccessible.

Provision for storing fruit and vegetables in the building was made by a special room, in which a proper temperature is maintained by means of a heating and of a refrigerating plant.

No difficulty was experienced with the foundations of the building, the columns resting on footings on the solid limestone rock which forms the banks of the Mississippi River at this point, the rock being not very far below the surface of the ground.

The building was designed under the direction of Mr. C. N. Kalk, chief engineer, and Mr. G. H. Leipold, assistant engineer, of the Wisconsin Central Railway. Mr. C. A. P. Turner, consulting engineer, Minneapolis, designed the reinforced concrete work, and Butler Brothers Company, of St. Paul, were the contractors.

An Ejector was recently used in cleaning out two concrete basins forming a part of a cooling tower plant. Each basin was 80 x 100 ft. in plan and 8 ft. deep, and formerly a large force of men was required for cleaning them. The ejector now employed for the purpose consists of a 5-in. pipe with one end flared slightly, into which opening a nozzle is inserted a few inches. This nozzle is 2-in. pipe drawn down to 1 in. The ejector removed all the water in each basin in 2 hr., and removed all dirt and rubbish that would pass through the 5-in. pipe; it was so successful that later it was used for pumping sand from a river bed.

Test of a Small Suction Gas Producer Plant.

The records of a test recently made upon a suction gas producer and engine plant at the Weber Wagon Works at 80th Street and Wallace Avenue, Chicago, Ill., were presented in a paper before the Western Society of Engineers on Feb. 5, 1908. The test was conducted for the purpose of determining the efficiency of the apparatus under a continued full load, the fuel consumption for variable loads and its adaptability to varying loads. No alterations were made from regular operating conditions other than such preparations for the test as the insertion of thermometer cups in various portions of the apparatus for temperature measurements, of water meters for measurements of water supplied to the vaporizer and scrubber, and of U-tubes for pressure measurements. Other provisions for the test consisted of means for weighing the fuel and ashes, a water cooled Prony brake for determining the power delivery of the engine, and an apparatus for gas analysis which was located in a small enclosure erected near the engine so that the analyzing apparatus was not subjected to changes in temperature or air currents.

The apparatus tested consisted of an Atkinson automatic suction gas producer of 15 horsepower rated capacity, and a horizontal single cylinder engine with hit-and-miss governor operating on a four-stroke cycle. The producer equipment which is designed for the gasification of anthracite coal, consists of the usual generator, vaporizer and scrubber, the latter being merely a coke filled tank through which the gas is passed from the generator to the engine for cleansing by water sprays from revolving spray arms. The generator consists of two vertical cast-iron cylinders, concentrically arranged, the inner cylinder being fire-brick lined and serving as the furnace or fire chamber while the space between the inner and other cells is an air-cooling jacket space through which air is passed for pre-heating before entering the vaporizer and thence to the fire. The inner furnace shell has a fuel magazine below the charging hopper from which the fresh fuel feeds down automatically as rapidly as that in the fire zone is consumed, and which holds coal enough to maintain a constant depth of the fuel bed for about one hour's operation at full capacity. The fuel charging device consists of a rotating cylinder which is filled through the hopper when turned upward and to dump its contents into the fuel magazine is revolved one-half turn. The producer is not fitted with a grate, the fuel column resting directly on a base of concrete in an open space under the base of the internal furnace cylinder, from which the ashes are removed at infrequent intervals through air-tight door openings in the outer shell.

TEST OF A 15-HP. SUCTION GAS-PRODUCER PLANT.

	Full Load.		Three-quarter Load.	Variable Load.
Length of test, hr	10	10	8	8
Coal used, lb.	164.75	173.5	133.0	137.75
Ashes removed, lb	17.25	21.25	18.75	33.0
Coal, lb., stand-by loss	26.5	16.0	15.0	19.25
Ashes, lb., stand-by	27.5	13.0	13.5	13.75
Total coal, full day, lb.	191.25	189.5	148.0	157.0
Total ashes, full day, lb.	44.75	34.25	42.25	46.75
Work done, hp. hours	160.6	162.0	102.7	83.2
Average hp. developed	16.1	16.2	12.9	10.4
Total rev. of engine	134,414	135,192	110,938	110,374
Average r.p.m. of engine	224.2	225.3	231.1	229.9
Water to vaporizer, lb	35.38	35.08	24.52	21.78
Water to scrubber, lb	3,135	3,483	3,534	9,178
Water to scrubber, gal	376.	418.	424.	1,101.
Average b.t.u. of gas at 62°, 30 in	111.0	113.3	112.0	109.9
B.t.u. in coal, for test	2,066,950	2,176,730	1,668,620	1,728,210
B.t.u. in ashes, for test	121,730	149,960	133,480	234,930
B.t.u. in coal, full day	2,399,420	2,377,470	1,856,810	1,969,720
B.t.u. in ashes, full day	315,800	241,700	300,700	332,815
B.t.u. per brake hp. hr., test run	12,870	13,440	16,250	20,770
B.t.u. per brake hp. hr., full day	14,940	14,600	18,080	23,680
Lbs. coal per brake hp. hr., test run	1.02	1.07	1.29	1.66
Lbs. coal per brake hp. hr., full day	1.19	1.17	1.43	1.88
Lbs. water per hp., vaporizer	0.22	0.22	0.24	0.26
Lbs. water per hp., scrubber	19.5	21.5	34.3	110.3
Lbs. coal per sq. ft. area per hr	15.4	16.2	15.6	16.1
Grate efficiency, per cent., full day	86.8	89.8	83.8	83.1
Efficiency of installation, per cent., test run	20.4	20.4	15.7	12.2
Efficiency of installation, per cent., full day	17.0	17.3	14.0	10.7

The vaporizer consists of a fluted cast-iron pipe within a cast-iron container shell, so connected that the gas passes from the generator through the inner fluted pipe on its way to the scrubber and in so doing gives up a large part of its heat in vaporizing water for the air supply to the fire. Water is fed by an automatic device as needed to the space between the fluted pipe and the container shell, through which the air is passed from the cooling jacket of the generator to the fire. The engine has an 8½-in. cylinder with 16-in. stroke and operates at 230 r.p.m. It was designed for producer gas, having a pressure of compression of 180 lb., and has "make and break" ignition.

In conducting the tests, it was arranged to supply weighed amounts of coal to the generator at 2½-hr. intervals, or oftener, and to remove and weigh the ashes at the termination of each run, while samples were taken of both coal and ashes during each run for analysis. Two full load tests were run, each of ten hours' duration on succeeding days, and subsequent to this there were two 8-hr. tests, one at three-quarter load and the other with variable loading. The results were figured on both a test run basis and also on a 24-hr. day basis. The only precautions taken prior to beginning the tests were a careful cleaning of the generator for the removal of clinkers from the fire-brick lining, the regrinding of the engine valves and the examination of all parts to insure their proper condition. Subsequent to this a preliminary run was made in which the Prony brake was attached to the engine and adjusted.

In all of the tests, the fire in the generator was blown up from banked condition about 1 hr. before the beginning of the run, the gases being initially wasted through the purge pipe in the usual manner, and the ashes raked out and the fire well cleaned. In both of the full load runs the engine was started under about three-quarter load which was shortly after increased to the full load rate. The various readings of pressures, temperatures, engine speeds, etc., were for the greater part taken at 30-min. intervals, with the exception of the gas analysis which were made at 1½-hr. intervals. No adjustments were made in the regulation of the air supply to the engines during the constant load runs, and no difficulties of any moment were experienced, but with the variable load run, trouble was experienced with the air valve which had to be readjusted whenever the load on the engines was changed by any considerable amount. The analysis of the coal showed its composition as follows: Moisture, 3.08 per cent; volatile matter, 7.41 per cent; ash, 11.07 per cent; and fixed carbon, 78.44 per cent. Its heating value as determined by a Mahler bomb calorimeter was 12,546 B.t.u. per pound. The ashes removed, which varied from 10 to 14 per cent by weight of the coal fed for the constant load runs and about 25 per cent for the variable load run, showed average heating values of slightly over 7,000 B. t.u. per pound. The analysis of the gas throughout the runs showed averages of from 32 to 40 per cent of CO_2; 0.6 to 1.1 of O_2; from 25 to 26.9 of CO; from 6.8 to 7.4 per cent of H_2; from 0.7 to 0.9 per cent of CH_4; and from 61.2 to 61.7 per cent of N_2. The results of the tests are presented in great detail in the paper. As a result of these figures a rating was assigned to the engine, based on the maximum horse-power, standardized, which the engine is capable of developing for a considerable period of time, multiplied by the factor which is adopted in practice, 85 per cent; as the engine developed an average 16.9 horse-power for two days at 225 r.p.m., the rating assigned for this speed is 14½ h.-p.

The conclusions drawn from the tests are that the results in regular operation were, on the whole, very satisfactory, the fuel consumption being very economical and much less, in fact, than has been obtained by producer plants of similar size in England. The fuel consumption at three-quarter load and variable loadings was shown to be in proper proportion to that at full load and also the producer was found capable of adjusting itself to make gas to meet the varying conditions. It was shown that the proportions of the generator so far as the area of the fuel column and its height are concerned, were satisfactory and ample for a 15-hp. producer and that the grate efficiency was comparatively high. Furthermore, the design of the generator without a grate proved satisfactory although the magazine directly underneath the feeding hopper proved to be too short as it does not contain a sufficient amount of coal for reserve purposes. Both the air jacket and the vaporizer was considered very effective in heating the air for rapid evaporation of the water supplied and the vaporizer was shown effective in materially reducing the temperature of the gas before entering the scrubber. The coal consumption per hour was proved to be nearly constant and apparently independent of the power developed for the load factors used.

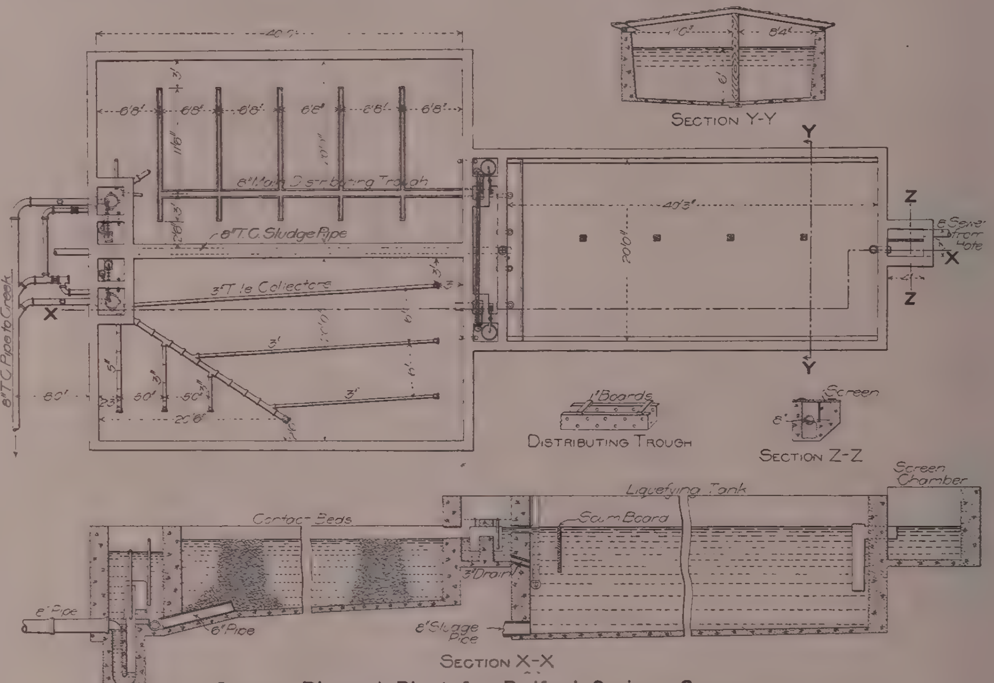
AN ELECTRIC PLANT for use at Gatun has been ordered from the General Electric Co. by the Isthmian Canal Commission for a direct-current connected load of 2,400 h.-p., an alternating-current connected load of 2,445 h.-p., a 300-kw. lighting load for Gatun and a 400-kw. lighting and power load for Colon and Cristobal. Current will be supplied from this plant for a number of 20-in. centrifugal pumps, several cableways, a cable railroad and concrete mixers at the Gatun works. There will be five 750-kw. turbo-generators running with steam at 150-lb. pressure, 140° superheat, and 28-in. vacuum at 30 in. barometer. They must have a continuous overload capacity of 50 per cent. and run 25 per cent. underload without a great drop in steam economy. There will be one condenser of 13,500 lb. condensed steam hourly capacity and two of double this size. Two horizontal rotative dry-vacuum pumps driven by simple non-condensing engines and two centrifugal circulating pumps driven by horizontal tandem compound engines will be used with the condensers. Three turbo-generator exciters will be used. The station will be equipped with a 20-ton single-trolley traveling electric crane. Three-phase current at 2,200 volts 25 cycles will be furnished, and there will be three 500-kw. rotary converters, each furnished with three 185-kw. oil-cooled transformers. The converter and transformer equipment may be changed for other types of apparatus, in accordance with alternative plans permitted in the specifications. There will also be six 100-kw. 2,200/6,600 transformers for use in connection with a 7-mile transmission line.

A Sewage Disposal Plant for a Large Hotel at Bedford, Pa.

By T. Chalkley Hatton.

The Bedford Springs Co. owns and operates a large hotel located about two miles from the borough of Bedford, in Pennsylvania. The hotel is open only from May to October of each year and is capable of accommodating about 400 guests. During this period there are approximately 100 employees about the hotel who live upon the premises. Upon the grounds are several springs which discharge large quantities of water highly charged with sulphur, iron and megnesia. This water flows into a small mountain brook which runs through the hotel grounds, and which is a natural vehicle for carrying off all the liquid wastes from the hotel.

Immediately adjoining the Bedford Springs Co.'s property is another smaller hotel, located on or near the banks of this brook, and the owners of the latter establishment, claiming that the sewage discharged into this brook from the larger hotel was creating a nuisance detrimental to their business, requested the Bedford Springs Co. tc dispose of this sewage in such manner as would remove the nuisance. The brook water is not used for domestic purposes throughout its length, but runs through a well developed agricultural community. Thus the nuisance created by the sewage discharged from the hotel premises was more ethical than real, and therefore the writer, who was engaged by the Bedford Springs Co. to solve the problem, considered that it was only necessary to remove the ocular evidence of sewage rather than to obtain an effluent of high standard.



Sewage Disposal Plant for Bedford Springs Company.

The only ground available for a sewage disposal plant was at the lower end of the hotel property, about 1,600 ft. from the hotel buildings, and about 800 ft. from the smaller hotel, which suffered from the nuisance. This ground has a gentle slope towards the brook and also in a direction parallel with the course of the brook. Its surface elevation was 5 ft. below the deepest drain coming from the hotel, thus precluding the construction of a gravity sprinkling filter, which the writer would have preferred. The sewage from the hotel was carried to the disposal plant through an 8-in. terra-cotta pipe which passed under the brook by an inverted siphon. From the hotel 16,000 gal. of sewage were discharged per day, half of which flowed to the disposal plant in eight hours, or at the rate of 24,000 gal. per day. In addition to this, there were 24,000 gal. of spring water which it was necessary to carry to the plant unless all the systems of piping about the hotel were changed. This water was very highly charged with sulphur, iron and magnesia, and the writer had serious doubts as to the effect these minerals would have upon the purification process.

The plant as built consists of a screen chamber, into which the sewage is first discharged; a wrought-iron vertical screen with ½-in. flat bars spaced 1 in. between centers; a covered, 20 x 40 ft. liquifying tank with an average depth of liquid of 5.42 ft.; a feed chamber, 14 x 2.75 x 1.89 ft.; two primary contact beds, each 20 x 40 ft. with an average depth of filtering material of 3.62 ft.; and a sludge bed having a capacity of 40,000 gal. All the plant except the sludge bed was built of concrete composed of 1 part of Portland cement, 2½ parts of washed sand, taken from the old bed of the brook, and 5 parts of gravel obtained from the same source. The gravel was all sizes from pea to 3 in. through largest section, but made a very good composition.

The contact beds are underdrained with 3-in. terra-cotta pipes connected with a 6-in. main underdrain, all of sufficient capacity to discharge the full contents of the bed in 40 minutes. At each end of each line of underdrains a standpipe is erected with its upper end projecting above the water line of the bed. A perforated cover is placed in the bell. Through these standpipes a free circulation of air may always be obtained when the bed is either filling or discharging.

The materials composing the filter beds are a bottom layer of about 6 in. of field stones from 2 in. to 5 in., placed about the underdrains, and 2 ft. 6 in. of coke, broken and screened to pass circular mesh screens of ¼-in. to 3-in. diameter. Each layer was placed evenly over the bed and graded from the coarsest at the bottom to finest on top. Over the top was placed a 6-in. layer of larger stones, collected from the adjoining fields. These were used primarily as a blanket to prevent the particles of coke from floating. Upon the surface of this blanket wooden troughs were placed at regular intervals, the sides of the troughs being perforated by ¾-in. holes through which the sewage drops to the stones below.

The plant was located so as to minimize the excavation, but in every case the foundations were started upon the natural ground. The sludge bed was made by excavating a shallow round hole in the ground below the contact beds, large enough to hold the full capacity of the liquifying tank. The sludge bed can be drained to the brook, the scheme being to thus discharge any rain water which the bed might contain before discharging the contents of the liquifying tank into it. The full contents of the liquifying tank will be retained in the sludge bed until most of the liquid evaporates or seeps away through the underlying gravel stratas, after which the solid deposit can be used as a fertilizer upon the farm connected with the hotel. As the necessity for using the disposal plant ceases each year about Oct. 1 provision has been made for draining out the whole plant except the sludge bed.

The contact beds are provided with the Adams-Miller automatic alternating feed and dosing siphons, and the Miller timed discharge siphons, which are set to regulate the filing, resting, discharging and standing empty of the beds in four-hour cycles; that is, filling four hours, resting one hour, discharging one hour, and standing empty one hour. This cycle fluctuates with the flow of sewage so that neither bed is operated two successive days with the same strength of sewage.

Main Dam Excavation from South Tower of Cableway.

The sewage is discharged into the liquifying tank through a 12-in. submerged pipe, and flows out through four submerged 4-in. pipes, each having a strainer at the intake end. A scum board is built across the tank directly in front of the outlet pipes. The tank has sufficient capacity to hold the maximum volume of sewage for 15 hours, the maximum velocity of the flow through the tank being ½ in. per minute.

The total cost of the plant, including engineering and inspection, and exclusive of land occupied, was $6,000. It was completed about July, 1905, when it was immediately put into operation. Within a month the liquifying tank contained a scum about 1 in. in thickness. Near the end of September the writer made an examination of the efficiency of the plant with the following result:

Parts per 100,000.

	Oxygen consumed.	FNH_3	Alb. NH_3	Per cent. of purification by oxygen consumed.
Raw sewage	4.82	2.00	0.624	..
Effluent	1.26	0.872	0.237	76

The raw sewage contained 584,000 bacteria per cubic centimeter, the effluent, 63,500, the percentage of purification biologically thus being 90. The writer considered this standard of purification high enough to remove the nuisance complained of, and as there have been no further complaints, the plant may be considered a successful one.

The sewage is a weak solution, and differs very much from the usual solutions from a municipality, because it contains no manufacturing liquid wastes of any kind, and one-half of it is unpolluted spring water. This condition, however, increases the problem of increasing the percentage of purification.

At the end of the first season it was found that much of the coke broke up and disintegrated into fine dust, much of which was carried off in the effluent. The next season crushed stone was added to bring the filtering material up to the required height.

Only one liquifying tank was provided because the plant is in operation only during the summer season, at the end of which it is completely drained out. The sludge accumulating during this period was not expected to attain such volume as to require that the tank be disturbed while in operation. In fact, at the end of the first season when the tank was emptied there was such a small amount of sludge that it was not thought worth while to clean it out.

The operation of the plant is entirely automatic, except that at intervals of three or four days the screen is raked. There is no apparent odor from it. The occupants of a dwelling located within 300 ft. of the plant have never complained of any odor. Except at such times as the disintegrated coke passes off in the effluent, the latter is clear and non-putrescible.

The writer believes that this kind of a plant is well suited to conditions which do not require the standard of purification to be high, which is the usual condition. If single contact beds can be made to serve instead of double contact beds, a saving of nearly half the cost of a disposal plant is effected as one of the chief expenditures is for filtering materials for the beds.

A Reinforced Concrete Tower will be built by the Aberthaw Construction Co. at Blue Hills, Mass., to replace the present masonry structure which leaks at the wall joints. It will have 4-in. double walls with a 10-in. air space and will be about 35 ft. high.

Construction of the Main Dam of the Croton Falls Reservoir.

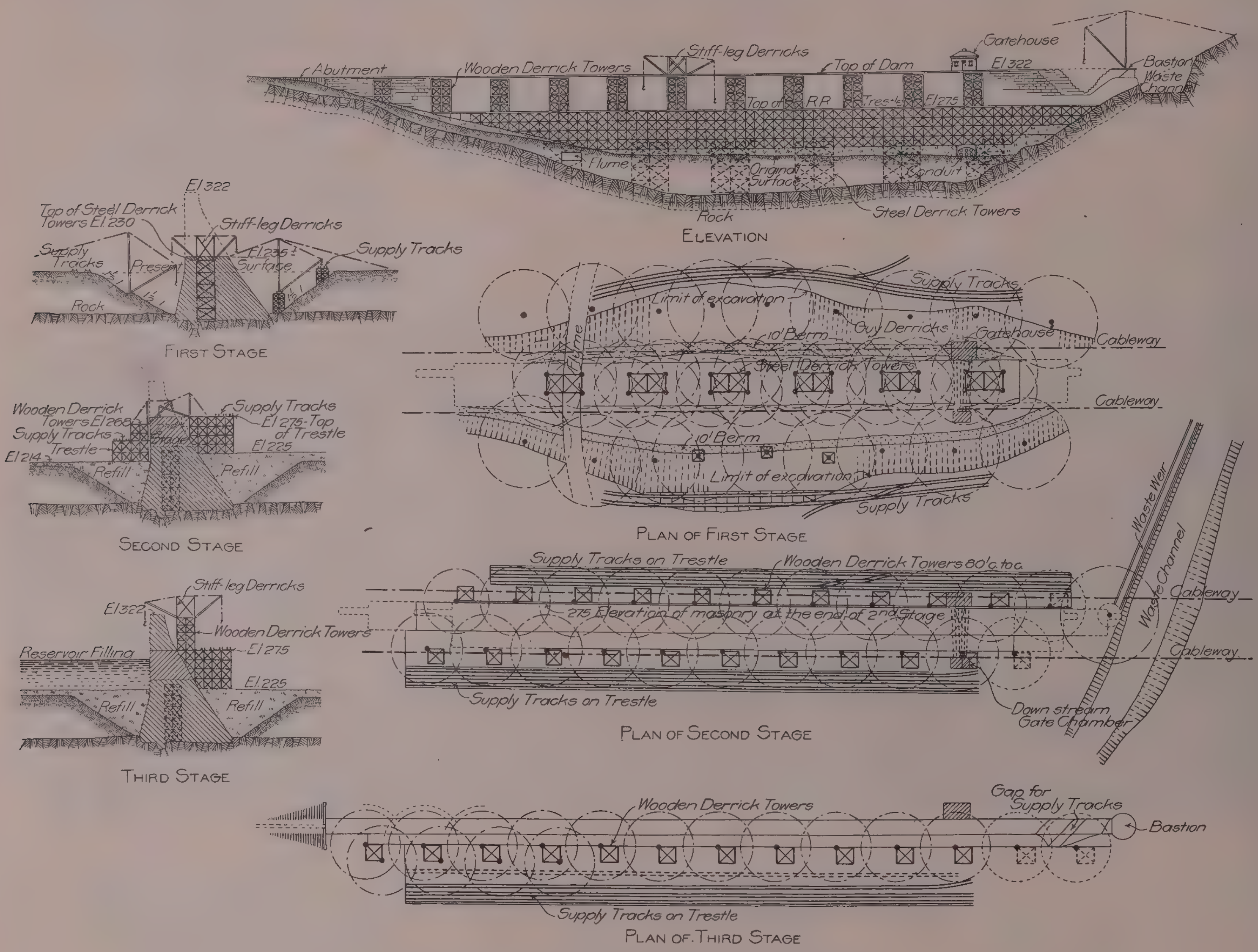
The construction of the 15,000 million gallon reservoir, near Croton Falls, Westchester County, N. Y., which was described in The Engineering Record of Jan. 18, includes a number of separate items, the most important of which are, the construction of the main dam and appurtenances including the temporary diversion of the stream; the construction of a permanent diverting dam and appurtenances; the construction of a permanent connecting channel and its appurtenances between the collecting and impounding reservoirs; clearing the 1,600-acre reservoir site; building about 15 miles of highway; bridges, culverts, fences, etc., and building about 10,000 lin. ft. of boundary stone wall enclosing the reservoir property. The estimated total cost of the work is $3,028,000 and the contract time for completion, March 23, 1909.

It was considered that speedy construction was imperative, in order to have the reservoir put in service at the earliest possible moment and the principal features of the design and the requirements of the specification together with the method of work proposed, the plans submitted, and the rate of progress demanded was fixed in view of this controlling consideration. The conditions of the work and the contractor's installations and methods are now sufficiently developed to show most of the general features involved and the more important ones will be described in the present and a succeeding article.

The main dam will contain about 240,000 cu. yd. of cyclopean masonry and will be faced with about 28,000 cu. yd. of large concrete cast blocks. It will be about 1,070 ft. long on the crest with maximum height and width of about 167 ft. and 125 ft. respectively. It is located with its axis approximately at right angles to the original bed of the stream and crosses from side to side of the deep valley with its foundations carried down to solid rock at a probable maximum depth of about 55 ft. below the original surface of the ground and about 52 ft. below the low water level of the river and 155 ft. below the flow line of the reservoir. At one end there is a waste channel about 170 ft. long quarried out of the solid rock in the hillside adjacent to the overflow weir 700 ft. long.

About 600 ft. above the dam the river makes an abrupt bend of 90 deg., and flows thence in a straight line close to the south side of the valley where the old channel in the solid rock had an average width of about 70 ft., and depth of about 6 ft. with an ordinary flow of about 200,000,000 gal. per day and a current of about 4 miles an hour. It is, however, subject to sudden floods, increasing the flow to a maximum of 900,000,000 gallons per day and causing it to overflow the full width of the bottom of the valley, about 600 ft.

To divert the river from the dam site during construction there are required two temporary earth dams, above and below the permanent main dam, connected by a paved channel and flume passing through the north end of the main dam as indicated in the accompanying location plan. These structures form a bypass to provide for the flow of the river until the masonry of the main dam is built up to elevation 225 and two 48-in. discharge pipes are installed in the lower part of the south end of it, when it is intended to close the flume and by means of a curved earthen dyke about 300 ft. upstream from the main dam, as indicated in the location plan, to divert the stream from an overflow in the upper temporary dam through a direct temporary new channel to the waste pipe. By this means the reservoir site can either be kept entirely dry during construction or the collection and storage of water there may be commenced at any time after the waste pipes are put in service.



System of Combined Falsework and Derrick Towers.

A 900 x 1,350-ft. area inclosing the site of the main dam and most of the waste channel was surveyed and laid out with longitudinal and transverse lines 100 ft. apart, on which, chiefly at their intersections, were made about 82 wash-drill borings, 12 diamond-drill borings and 39 open test pits, most of the latter being sunk at the two ends of the dam and around the lines of the waste channel. The 2-in. pipe casings were permanently left in two of them to provide wells for the observation of fluctuations in the ground water level. Nearly all of the borings were made on seven lines parallel to the axis of the dam and from their records seven sectional profiles were plotted which indicated the surface of the rock to be approximately parallel with the bottom of the valley and at a maximum depth of about 60 ft. below the surface. The materials encountered appeared to be, top soil and fine sand, gravel and boulders, fine sand, coarse sand, pockets of quick sand, and sand, gravel and boulders, in approximately horizontal strata of varying depth. So far these indications have been substantially confirmed by excavation and the gneiss rock exposed has a dip corresponding in general to the cross section of the valley and an irregular stratification with unsound or decomposed portions in the upper part.

The contract schedule required that within three months after the award of the contract on Aug. 23, 1906, the river should be diverted from the dam site and 6 per cent. of the total work done, and that during the season of 1907 the main dam should be completed at least to elevation 225. Various other progress requirements were made in the specifications, some of which have been exceeded and some of which have not been attained.

At the main dam laborers' camps have been established and most of the contractor's plant installed, the temporary river diversion has been completed and 180,000 cu. yd. of a total of 240,000 yd. of earth excavation had been finished Jan. 1, exposing the surface of the bed rock down to a maximum depth of 65 ft. Rock excavation has been commenced, the waste channel above the dam has been practically completed, a quarry opened and about 15 miles of railroad track laid.

About the first work done was the construction of 2½ miles of standard gauge connecting track from a point on the Harlem Branch of the New York Central & Hudson River Railroad, about two miles south of Brewster Station, near the diverting dam site, to the site of the main dam. This was supplemented by various branches of standard gauge and 3-ft. tracks, connecting the different parts of the work to provide for the transportation of plant and materials and for hauling spoil. There are virtually two systems of tracks, one in the bottom of the valley between the main and diverting dams at elevation about 222 and the other at elevation 310, connected with it by a switch-back system. All of the standard gauge tracks have a third rail to provide for the narrow gauge rolling stock and are carefully laid with 60-lb. and 80-lb. rails. The intersection of these three-rail tracks at a point near the diverting dam developed a rather difficult problem in crossings which was solved by the use of special frogs.

Excavation was commenced on the main dam temporary diversion channel where a 2½-yd. Bucyrus steam shovel was installed and removed about 50,000 cu. yd. of earth. After completing this work the shovel was transferred to the main dam where with two other steam shovels the earth has been excavated at a maximum rate of about 1,000 cu. yd. per shovel per day and removed by trains of 4-yd. Continental and Western dump cars drawn up a maximum grade of 5 per cent. by steam locomotives manufactured by the Vulcan Company. Usually one locomotive was able to haul a train of four to six cars up the maximum grade, but sometimes a helper locomotive was needed. Care has been taken to deposit the spoil where it will not require rehandling and where it can be utilized in leveling up necessary yard room in convenient locations. All of the spoil from the main excavation has been deposited upstream where a plateau of about 6½ acres has been formed at elevation 222 to provide a yard for casting and storing the concrete face blacks.

The construction of the spur line to the Harlem Railroad involved considerable costly and heavy work including cuts 29 ft. deep, chiefly in rock, together with the earth cuts making a total of about 270,000 cu. yd. of excavation, nearly all of which was balanced so as to be advantageously used to fill in adjacent embankments requiring an average haul of about 750 ft.

Rock Surface in Main Dam Excavation, Jan. 3, 1908.

The rock excavation for the foundations of the main dam has just been commenced and there have been installed for it 34 Sullivan, Murphy, and Ingersoll steam drills and 16 guyed derricks, the latter located about 80 ft. apart in the bottom of the valley in two parallel lines, one each side of the dam. The derricks are operated and swung by independent steam hoisting engines which later will be run by compressed air and have booms from 65 to 90 ft. in length and 12 ton capacity, many of which were brought here from the Connecticut Avenue Bridge, Washington, described in The Engineering Record of Feb. 16, 1907, which was built by the same contractors.

The river diversion work has proved efficient and no serious trouble has been encountered from the water, although a considerable quantity has collected in the deep excavation and it has been removed by one 6-in. and one 10-in. Emerson centrifugal pumps and by four Cameron pumps with discharge pipes of 4 in., 5 in., 7 in., and 4 in. diameter. All of the pumps, except two of the small Camerons, take their suction from a central sump at elevation 160, and discharge at elevation 222 into a trough delivering to the diversion channel. The pumps and hoisting engines are at present operated by steam from an adjacent power plant equipped with one 500-h.p. vertical Wicke's boiler and three auxiliary locomotive boilers held in reserve in case of emergency. These, however, will be superseded by compressed air when the main power station is completed. Rock excavation is in progress in the waste channel below the dam where a steam shovel is used to load the shattered stone on the dump cars.

The temporary diversion dam upstream from the main dam is about 800 ft. long and 16 ft. in maximum height and is 7 ft. wide on top with 2:1 slopes. In order to avoid overflow in times of extreme flood, it is provided with an overfall 60 ft. long and about 5 ft. below the crest of the dam. The overfall is built of timber crib work, filled with stone and sheeted on the top and upstream sides. A sheet pile cut-off and a 3:1 back fill slope protects the upper side and the lower face is made in 24-in. horizontal steps over which the water is discharged on a horizontal timber apron about 36 ft. wide carefully bedded on the surface of the ground, and extending 14 ft. beyond the toe of the dam. The dam at the lower end of the temporary diversion channel is about 650 ft. long and 14 ft. high and is similar to it except that it is not provided with an overfall.

The diverting flume has an enlarged inlet with side walls parallel and adjacent to the diverting dam. The normal cross section of the flume is 24 ft. wide and 8 ft. 2 in. deep inside, and has an estimated capacity of 1,000,000,000 gal. per day. The present flow of about 200,000,000 gal. fills it about one-third full. Except where it passes through the dam the flume is built in a trench and is seated on 8 x 12-in. transverse sills 37 ft. long and 5 ft. apart. Vertical 8 x 8-in. posts and 6 x 8-in. knee braces are mortised into the sill and the tops of the posts are mortised into horizontal tie pieces about 30 ft. long. The bottom and sides of the flume are covered with undressed square edge pine boards, 2 in. thick, laid close without special joints and covered with 2 thicknesses of tar paper protected by an inside sheeting of 1-in. tongue and groove boards, a construction which has proved very satisfactory and water tight.

In the cuts the flume is back-filled to the tops of the knee braces and where it crosses the dam it is supported for a length of 75 ft. on permanent transverse steel trestle bents. This portion of the flume is special in that the upper transverse round tie pieces are replaced by pairs of 2 x 12-in. planks bolted to the vertical pieces and that the latter are connected by single horizontal ¾-in. tie rods with screw ends passing through their upper ends. Single vertical ¾-in. tie rods with screw ends also connect the extremities of the caps and sill pieces outside of the flume, thus clamping the entire structure firmly together and strengthening it against settlement or distortion.

The foundations for the steel trestles supporting the flumes are carried down to sound rock at the level of the dam foundation and it is intended that the steel work shall be built solid into the body of the dam and grouted there, thus avoiding any delay, obstruction or changing as the work progresses. Each bent has three vertical posts composed of single 12-in. I-beams with angle iron caps and bases and transverse X-bracing made with single 4 x 3 x ⅜-in. angles and zig-zag longitudinal bracing between bents made with the same materials. The bents are capped with 20-in. 65-lb. I-beams 24 ft. long which support on their top flanges four equidistant pairs of 15-in. 60-lb. I-beams bolted together with separators and carrying the sills of the flume. The total weight of the steel trestle is about 66,000 lb. and the contractor is paid for it as a part of the regular structure.

In order to secure the earliest possible completion of the work the contract specifically requires that special means and facilities for rapid construction shall be provided, including "permanent derrick towers built within the dam, large temporary trestles for derricks and cars close to the dam, and railroads and roads for transportation of materials, with large numbers of cars, engines, vehicles and draft animals, cable-ways and other rapid conveying machinery; a large equipment of power tools, power drills, quarrying tools and excavating machinery; concrete making machinery of large capacity; special equipments for handling concrete blocks; and pumping plants of liberal capacity."

The contractor is also required to keep constantly on hand at the works reserve duplicates of such parts of the machinery and other appliances as are most likely to be broken and lost, thus reducing to a minimum necessary delays in operation.

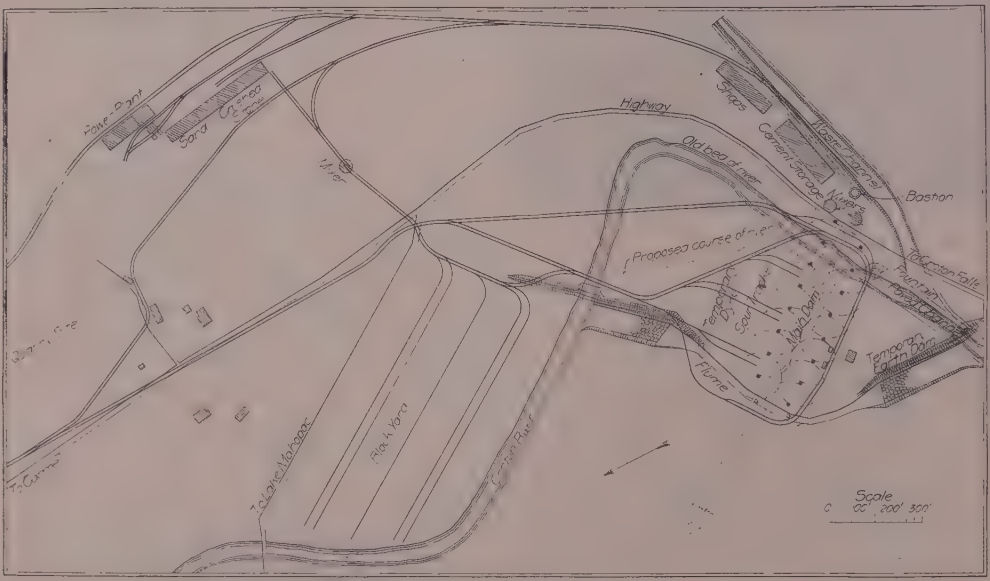
The contract drawings include general plans, elevation and cross section, showing the arrangement of plans suggested for the expeditious construction of masonry in the main dam. This provides for the installation of two traveling cableways of at least 10 tons capacity and eleven steel towers of an estimated total weight of 434,000 lb., to be built permanently into the masonry. The derrick towers are all to be seated on the bed rock and to have different heights extending up to elevation 230 with a uniform width of 25 ft., transverse to the axis of the dam and lengths of 60 ft. parallel to the axis. Each is to have six vertical posts made with a pair of 12-in. channels riveted together to form a T-shaped cross section. Each space is divided into 17-ft, stories by single 8-in. horizontal channels and all vertical panels are X-braced with single 5 x 3½ x 7/16-in. angles stayed by vertical 4 x 3-in. angles at their intersections. At the top of the tower and in the first and third stories from the bottom there is to be horizontal X-bracing of single 4 x 3-in. angles and the tops of the columns are to be capped with 18-in. 55-lb. longitudinal I-beams connected by 12-in. transverse I-beams 5 ft. apart. Stiff-leg derricks on each of the four corners of each of the towers are to be supplemented by auxiliary guyed derricks clear of the masonry on both sides of the dam.

Throughout the operations part of the materials are to be handled by the cableways and the remainder delivered to the auxiliary derricks by service tracks approximately parallel with the axis of the dam on both upstream and downstream sides. In the first stage of operations materials are to be delivered to the upstream face of the dam on supply tracks laid on the surface of the ground at elevation 230 and transferred to the tower derricks by auxiliary derricks seated on a berm about half-way between the rock foundation and the top of the bank. The double track supply lines on the downstream face of the dam are to be partly carried on the surface of the ground and partly on a wooden trestle, both at elevation about 230. The auxiliary derricks on this side of the dam are to be seated on wooden falsework towers at elevation about 190 and it is proposed with this arrangement to build the masonry up to elevation about 235 which will provide for laying about 75 per cent. of the masonry continuously without any interruptions for shifting the plants.

In the second stage of operations the excavation is shown back-filled up to elevation 225, approximately the original surface of the soil, on the downstream side, and up to elevation 214 on the upstream side with wide wooden falsework trestles built on it and up against the faces of the masonry on both sides of the dam, each of them carrying three lines of surface tracks and one line of stiff-leg derricks just clear of the masonry and commanding the whole of it.

On the upstream side the falsework is to be built up to elevation 245, at which level the service tracks are to be located and two-story wooden towers 23 ft. high are to be seated to support one stiff-leg derrick on each tower. On the opposite side of the dam the falsework is to be carried up to elevation 275 where the supply tracks and the auxiliary derricks are to be located on it at the same level. With this arrangement the masonry will be brought up to elevation 275, leaving only a small per cent. of the whole volume to be laid by the third stage operations.

At the end of the second stage the upstream falsework and derricks are to be removed, allowing water to be impounded during the final stage and all of the materials are to be handled by the cableway and by the downstream derricks which are then to be raised to the tops of wooden falsework towers about 45 ft. high, seated on the trestles. During the first stage of operations the river water is to be carried through the dam in the flume at the north end, and during the second and third stages it is either to be impounded or wasted through the 48-in. pipes controlled in the gate chamber or through an opening left, if necessary, in the masonry at the south end of the dam to provide for excessive floods.



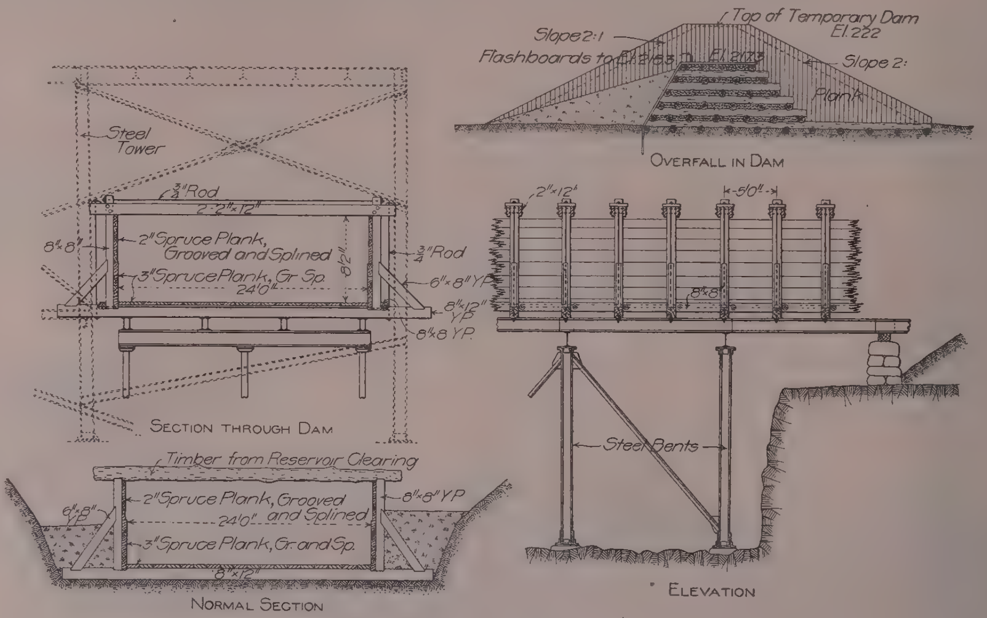
Contractor's Plant Location..

The specifications are somewhat ambiguous concerning the methods to be followed in the construction of the main dam since they state that the contractors shall provide, equip and use the steel derrick towers and then add that he may modify this design with the approval of the engineer, or submit other designs.

As it is believed that a larger amount of cyclopean masonry can be built into the concrete of the dam and that the work can be executed as quick or more quickly without the use of the steel derrick tower, and as the erection and maintenance of the large amount of wooden falsework is rather difficult and dangerous and subject to some degree of risk from fire, the contractor desires to eliminate the steel derrick towers, thus effecting an economy for the city and securing conditions believed to be more advantageous for himself.

The alternative plan proposed by the contractor and favorably considered by the engineers, contemplates the delivery of all the stone by surface tracks to a row of low level derricks on each side of the dam, which for the lower part of the structure will place it directly in position and for the upper part will deliver it to the cableway, which will also receive all concrete and distribute it as required, thus entirely obviating any change in the position of the derricks after they are set for the first work in the bottom of the dam.

In accordance with this plan 16 derricks have already been set to command the middle portion of the dam and are arranged, as indicated in the accompanying location plan, about 80 ft. apart, in two nearly parallel rows about 300 ft. apart. This disposition commands every portion of that part of the dam and gives double service to a considerable area where the boom circles overlap. Pending the installation of the cableway between the rows of derricks the latter and the steam shovels have been used for handling 193,000 cu. yd. of earth and 11,000 cu. yd. of rock excavated and loaded on special 4-yd. Continental side-dump cars operated by steam locomotives which have drawn them in trains of four cars each up the maximum 5 per cent. grade.



Bypass Flume around Main Dam.

The cars are operated on surface tracks at present arranged, as indicated, to form a double line on the downstream face of the dam at about elevation 222 and converging on the upstream side, near the old river channel at a point where several tracks converge from the block casting yard, from the concrete mixers, from the power plant, and from the main spur to the Harlem River R. R. A switchback at the quarry connects the low level tracks in the bottom of the valley with the main line and with the branch to the waste-way at a maximum elevation of about 295.

Six spur lines diverge from the loop enclosing the dam and are run perpendicular to its axis at elevation 222 terminating close to the upstream face where it is intended to erect platforms for the temporary storage of cyclopean stones which they will deliver to the upstream derricks that will pass it to the masons on the lower part of the dam, or after the masonry has reached elevation 245 will deliver to the cableways which will lay it in place. The contractors estimate that in the early part of the work, when the cableway handles concrete only, its efficiency will be increased at least 25 per cent., and that the masonry can be laid at the rate of 1,000 cu. yd. per day.

The derricks are operated with hoisting engines of Lidgerwood, Mundy, Rawson & Morrison, American Hoist & Derrick Co., and other standard makes which are at present run with steam from an auxiliary plant of 400 h.p., developed in one Wicke's vertical boiler located on the downstream side of the dam and supplemented by three locomotive boilers intended for use in emergency. As soon as the main power plant is completed it will furnish compressed air to supersede steam for the hoisting engines, cableways, drills, and other plant, excepting the steam shovels and locomotives.

The two 1,400-ft. Lidgerwood cableways have head and tail towers respectively 75 ft. and 105 ft. in height which travel at elevation 385 on three-rail tracks 385 ft. long at elevation 322 beyond the ends of the dam where horizontal terraces have been leveled to receive them. The minimum distance between the crest of the dam and the main cables under maximum center load is 40 ft., thus giving ample clearance for the finished construction. The cableways have a capacity of 30,000 lb. load with a hoisting speed of 300 ft., and a trolley speed of 1,200 ft. per minute and it is estimated that each trolley can make 15 round trips from the concrete mixer per hour, carrying one 2-yd. bucket of concrete at each trip.

Rock satisfactory for the foundations of portions of the dam has already been exposed and the excavation of unsound rock in other parts is in progress and has advanced far enough so that it will be possible to commence laying masonry as soon as the season permits uninterrupted work.

Two Hains concrete mixers of a capacity of 40 cu. yd. per hour are now being installed at the south end of the dam, close to the cement storage house, where their product can be delivered directly by cars to the cableway, and a third similar mixer is being installed near the concrete block storage yard where, at an early date, a large number of blocks will probably be cast on cars in order to have sufficient seasoning to be ready for use early in the Spring. It is proposed to provide a large number of flat cars on each of which five or six block moulds will be set and the car run so close to the concrete mixer that the latter can discharge directly into the moulds, thus saving all handling of the concrete. After the blocks are 90 days old, they will be removed from the car to storage in the yard and the cars restored to service.

The facing of the dam will be carried up somewhat in advance of the interior masonry and the upper surface of both will be kept approximately horizontal, both transversely and longitudinally, except that, as a precaution against extraordinary floods, a portion about 50 ft. long near the river channel at the north end of the dam may be maintained about 5 ft. lower than the up-stream face of the dam. Racking will not be allowed except by special permission of the engineer. Wet concrete will be deposited in the low places and cyclopean stones immediately set in it as close together as possible. They will be joggled with bars, and jarred to settle them well into the concrete and the concrete thoroughly worked with tools to insure filling all spaces between and beneath the stones and to permit the escape of entrained air. Small stones will be packed in the interstices between large ones so as to obtain a monolithic mass of stone and concrete with the largest possible proportion of stone.

The main quarry for cyclopean stone has been opened about 3,500 ft. north of the dam on the east side of the valley, a nearly vertical face about 125 ft. high and 700 ft. long has been stripped and the stone appears to be sound and of good quality in approximately horizontal strata from 3 to 10 ft. deep. The quarry is served by the double tracks of the contractor's main line connecting with the Harlem R. R. and in it are now installed two 10-ton 65-ft. boom derricks and three well drills of Cyclone and Keystone make, with which holes about 6 in. in diameter are drilled about 30 ft. apart and 25 ft. back from the face to a total depth of over 100 ft. so as to penetrate about 6 ft. below the bottom of the face. Each of these holes is drilled by a gang of three men at an average rate of about 15 ft. per day and is sprung once or twice with small charges of dynamite so as to enlarge the bottoms until they will receive about 8,000 lb. of dynamite. It is expected than one row of holes will throw down and shatter perhaps 70,000 cu. yd. of rock, most of which will be in condition to be loaded immediately on cars and transported to the rock crushers or to the dam site for use in cyclopean masonry. Two more quarry sites have been selected and partially stripped ready for development as soon as more stone is needed, and a number of test pits have been dug in the valley above the dam, demonstrating the existence of large quantities of sand suitable for concrete which will be secured there.

The plans have been made and the work is being executed under the direction of Mr. Walter H. Sears, chief engineer, Mr. Wm. H. Burr, expert engineer, Mr. Geo. A. Taber, assistant engineer, Mr. F. S. Cook, division engineer and Mr. C. E. Smith, engineer in charge of main dam, Mr. W. Houck, assistant engineer in charge of diverting dam and Mr. C. E. Benedict, assistant engineer in charge of highways. The contract was awarded Aug. 23, 1906, at a total unit price of $3,028,000 for the estimated quantities, to the Croton Falls Construction Co., Mr. J. F. Cogan, president; Mr. P. J. Cogan, secretary and treasurer; Mr. P. H. Cogan, superintendent, and Mr. I. J. Forchner, manager.

The Storage of Anthracite Coal.

Storage facilities have been increased by the anthracite coal mining companies within the last five or six years to an extent that few people outside the coal business realize. It was recently estimated that the reserve supply kept in storage is one-tenth of the annual production. Strikes, interrupting production, were largely responsible for the recent widespread and rapid construction of plants where fuel can now be accumulated. The object of the companies is to render the coal supply steady so as to prevent the sudden fluctuations in the market which have been, at certain periods, very embarrassing to the entire public. A great outlay of money has been made for mechanically operated plants on the Atlantic seaboard, in the coal regions, on the Great Lakes and along the lines of the railroads. The result of the outlay is expected to be a year-round tranquillity in the coal trade so far as a fuel famine is concerned. Though the investment is one of the kind that in itself brings in no return, it had to be made. The growing demand and the possibility of future interruptions of mining made ample storage an absolute necessity. It is not many years since the storage of anthracite coal, compared with other branches of the industry, was regarded as comparatively unimportant. Now, nothing is more essential to a producing company than to have ample reserve which can be drawn upon at any moment for vast quantities of fuel in case of a strike or any other untoward circumstance. When it is considered that the marketable output of anthracite last year was 67,109,393 tons, the extent of a 10 per cent. reserve can be appreciated, and new plants are being built continually, in order that storage accommodations may not shrink as production increases. Even as little as ten years ago the thought that production would ever reach its present volume never occurred to the mining man. In 1898 the marketable output of anthracite, which does not include the coal used by the companies and at the mines, was only 41,899,751 tons. There had been no appreciable change from year to year since 1890. In 1899 there was a jump to 47,000,000 tons, with a serious relapse in the year of the big strike, 1902, and from then on were recorded big jumps in the amount.

Interruptions in coal mining introduced a general uncertainty. Labor troubles, or the fear of them, had their inevitable effect upon prices. Neither the operator, nor the consumer, nor the mine laborer knew what was going to happen next. The supply of fuel depended largely upon the daily output at the mines. When work stopped there the demand pressed so hard that there was apt to be a scramble for coal. It was in these troublous times in the coal trade that a new impetus was given to the building and equipping of storage plants. Not only were they to provide against strikes, but also to enable mining to go on throughout the year, evenly and undisturbed. The great demand comes, of course, in the winter, but if storage accommodations are available there is no reason why the miners should not work just as busily during the warm weather.

Storage plants represent a large part of the capitalization of anthracite coal companies. The fact that they bring no direct profit in themselves can not delay their construction. The machinery with which they are equipped, though costly, is as necessary these days as the storage piles. If anthracite production continues to increase as it has increased in past years, more and more capital will be required to be put into storage plants. For it is fairly certain that a percentage of reserve to total will never be allowed to fall off.

As anthracite and bituminous coal differ in chemical composition and in the manner of their mining, so are they very differently stored. As a rule, bituminous coal is stored by the consumer or by some middleman. Anthracite, on the other hand, has to be stored by the producing company. This is due in part to the fluctuation in the demand for the several sizes of the hard coal. Bituminous coal being uniform, not divisible in sizes, the supply can be adapted to the demand with a fair degree of accuracy. But the sizes of anthracite rank as separate commodities, and if the demand for one variety falls off that variety has to be stored to await a better market. If it were possible to mine just the sort of anthracite desired during a given period, the problem of storage would be simplified. But the production of the various sizes is entirely independent of the market; they have to be taken out of the ground together, and unless they can be readily stored a healthy state of trade is impossible.

Bituminous coal must be stored in piles not more than 35 ft. high, to avoid the danger of spontaneous combustion. Anthracite can be stored in much deeper piles. It can be handled with bucket conveyors and other similar implements, on account of its hardness, but it must be so handled that excessive breakage will not result. Breakage is a most important consideration in the anthracite industry, because the smaller the coal the lower the price. Every piece of coal that breaks means so much transferred from a superior to an inferior variety.

A coal storage plant typical of one type of construction is the new one of the Lehigh Valley Coal Co. at South Chicago. It has a comfortable capacity of 125,000 tons, but this could be stretched under necessity. The structure is 540 ft. long, 231 ft. wide and 72 ft. high. This plant is covered. In a cold climate anthracite freezes unless it is protected from the weather. In a moderate climate it may prove more economical to take chances on the weather; the number of days of freezing temperature may be so small that the loss will not be great. In regions where it is sure to be cold several months every year, there has to be a roof, although its cost may be high. The dock replaces one that was burned down in 1906. The new dock is of concrete and steel and was designed to be an absolutely fireproof structure.

The mechanical equipment is so complete that thirteen men are all that are required for the working force now, and twenty will be ample in the season of open navigation, when boats arrive daily with cargoes to be unloaded. By means of a car loader four men do the work which required thirty-four formerly. Five hoisting towers rise from the wharf, each operating a grab-bucket that holds a ton and a half. A bucket conveyor is so constructed that it carries coal simultaneously in opposite directions, both the top and the bottom lines of buckets being utilized.

The dock is equally accessible from the water and the railroads. Most of the coal is received by lake. It can be stored to await shipment, or it can be put through revolving screens and immediately reloaded into cars. The car is placed on a sort of cradling device, which rocks it as the coal is poured in, thus scattering the coal over the entire floor. The loading of a car requires only five or six minutes. As fast as one car is drawn off a cable another descends from a hump by gravity and is ready to take on its load. When the locomotives arrive they find complete trains waiting for them.

This South Chicago storage plant is divided into three parts inside, each part being for one sort of coal. The partitions are movable, so that the sections can be enlarged or made smaller, in accordance with the condition of the market. If there is a great demand for nut coal, for example, the supply of it may be rapidly depleted, and its section will then be reduced in size; at the same time the pea coal section may be enlarged for the putting away of a large supply.

In the same way the uncovered outdoor storage plants have their separate piles, each pile set apart for one size of coal. The loading and unloading mechanism is very much like that of a plant with a roof. The railroad tracks occupy a long avenue between the parallel rows of coal piles, and the cars may be loaded on the one side or the other at will.

It is a fact perhaps little known that New York City and some of the vessels in its harbor consume at least one-eighth of the country's total output of anthracite coal. The strict regulations against defiling the atmosphere with black smoke make it impossible to use bituminous coal, except with smoke-consumers. The adoption of these is not warranted from the standpoint of economy, except in cases where the consumption of coal is very great, as in power houses and factories; hence the demand for the cleaner anthracite.

This market in New York means, of course, that the nearby storage facilities must be enormous. The large railway and coal mining companies all have their tidewater plants, where the coal is stored for ultimate delivery in New York. The Philadelphia & Reading, the Central of New Jersey, the Lehigh Valley, the Lackawanna, the Delaware & Hudson, all of the so-called anthracite coal roads, discharge trainloads of coal at these plants every day in the year. Not only along the Hudson River and on the shores of New York Bay, but down the New Jersey coast and in the suburbs several miles inland the pockets and the conical, uncovered piles of coal are to be seen.

Taking in its facilities everywhere, one company, it is estimated, has a storage capacity of 2,000,000 tons. Four hundred and eighty thousand tons can be stored by the Philadelphia & Reading Coal & Iron Co. at Abrams, Pa. The Lehigh Valley plant at Ransom, Pa., which has one continuous pile, is estimated to hold 383,000 tons. Three hundred and seventy thousand tons can be kept at South Plainfield, N. J., without the plant being overtaxed. At Abrams the coal is divided into eight piles, each with a capacity of 60,000 tons. By means of the machinery it is possible to stock 14,400 tons in a day of ten hours, and the coal can be reloaded into cars at the rate of 10,000 tons a day.

An immense slanting truss with a chain conveyor, constituting what is known as a "trimmer," is a conspicuous feature of one type of outdoor coal-storage plant. By the conveyor coal is delivered, to begin with, upon the ground, and then at the ascending apex of the pile. Gradually the mass of coal grows higher and higher, forming a bulky cone. The movable trough bottom of the conveyor makes it easy to change the point at which the load is emptied. This discharge point is kept a little in advance of the apex of the cone, so that a gentle fall is effected, and breakage is reduced to a minimum. In a reloading conveyor, often running in a tunnel beneath the level of the pile, the coal is carried to the reloading tower. There it is screened before being chuted into the cars for shipment. The mechanism through which the coal is sent into the reloading conveyor is capable of reaching any part of the entire storage area.

At one time or another every shipper is apt to experience the embarrassment of having to use box cars to transport his coal. To make this operation easy a "box-car loader" has been invented. The one at Ransom has a capacity of twelve cars an hour. The machine consists of an oscillating cradle. When the car is on the cradle the axis of rotation is straight through the middle of the side doors. The door openings are bulkheaded to a height of 3 ft., and the loading begins. As the coal streams in the cradle lets one end of the car down, filling that end, and then lets the other end down, to be filled in its turn. It would seem that the coal would fall back when the loaded end is tilted up; but it does not, owing to the fact that a sharper angle is required to start coal from rest than to keep moving coal that is already in motion.

The screening and resizing of coal that is being taken out of storage is an important feature. Inevitably some breakage, even if it be little, must take place during the coal's passage through the plant. After the small pieces are separated from the other coal a large percentage of the so-called screenings can be saved by resizing. When this is carried out in a systematic manner, as it is in the modern anthracite storage plant, the resulting economy is not to be despised.

Elaborate provisions have to be made for "melting out" anthracite during cold snaps. If snow falls and melts, and then the mercury drops below the freezing point, the limit of bad conditions has been reached. The coal, either in a car or on the pile on the ground, becomes a solid mass, which is more like rock than coal. Extra forces of laborers must be employed to attack the frozen mass with picks, and steam must be applied to loosen the great lumps. When New York was in the grip of its worst cold spell this winter the superintendent of one of the big coal docks on the New Jersey shore said that he had to employ just twice as many workmen as ordinarily. Here the cars that come direct from the mines unload their coal into the scows of New York dealers, and a big surplus is also kept in bins under the tracks. The coal in both the cars and in the bins was frozen.

A boiler plant to supply steam for melting purposes solely was built at this dock some time ago. It is used for only a few days each year—that is, when the coal freezes. When that time comes the steam is sent over the company's docks and yards in pipes. The men stick the pipes down into the coal, and in this way warm the coal into such a condition that it can be moved through chutes, which at best is very slow work.

An Automatic Switch-Point Closer is in use on the Boston & Maine R.R. for the purpose of positively closing switches in facing point movements and preventing derailments due to bent switch rods or switch levers not wholly thrown over. The device consists of a short detector bar and gear on one of the rails ahead of the facing point and so connected to the switch gear that if the switch-point stands partly open, the detector bar will project above the head of the rail. The result is that the first wheel of a car or train approaching the point in a facing movement will depress the detector bar and positively close the switch. Numerous tests of the device with the switch bars purposely bent and switch levers only partially thrown have proved its effectiveness. The apparatus was devised by Mr. J. W. McManama, roadmaster of the Fitchburg division at Waltham, Mass.

Tests of Boiler Settings by the Board of Education, Chicago, Ill.

A series of tests have recently been carried out by the Board of Education of Chicago to determine the relative suitability of a suggested form of boiler setting, as compared with the standard setting in use in the school buildings. The Department of Smoke Inspection of the city had, in its efforts toward smoke abatement, refused to issue further permits for the installation of new heating plants in school buildings under construction, unless the boilers were fitted with furnaces conforming in structural detail to certain designs advocated by the City Smoke Inspector. As a standard form of setting had previously been adopted and was in extensive use throughout the school buildings, it was thought desirable to make comparative tests of the suggested setting which make use of a firebrick enclosed furnace, and the standard setting of the Board of Education which was designed by Mr. T. J. Waters, its chief engineer.

The setting proposed by the Smoke Inspector has its furnace entirely enclosed by a fire-brick arch that extends back under the boiler shell to a considerable distance beyond the bridge wall, where the gases descend and pass through two large ports in a secondary bridge wall before entering the combustion chamber to the rear. In this space there are first two inwardly projecting wing walls, and beyond another dividing baffle in the form of a fire-brick pier or enclosure built up so as to protect the boiler blow-off connection. The Waters design of setting follows the more usual construction for use with bituminous coals, differing mainly in proportions and the use of auxiliary air-ports in the bridge wall and in the front above the fire door for the admission of air above the fire and of a narrow fire-brick arch, 12 in. in width, which is passed over the furnace above the center of the grates. The details of construction of either type of setting, as applied to a 60-in. x 18-ft. return tubular boiler, are illustrated in the accompanying drawing.

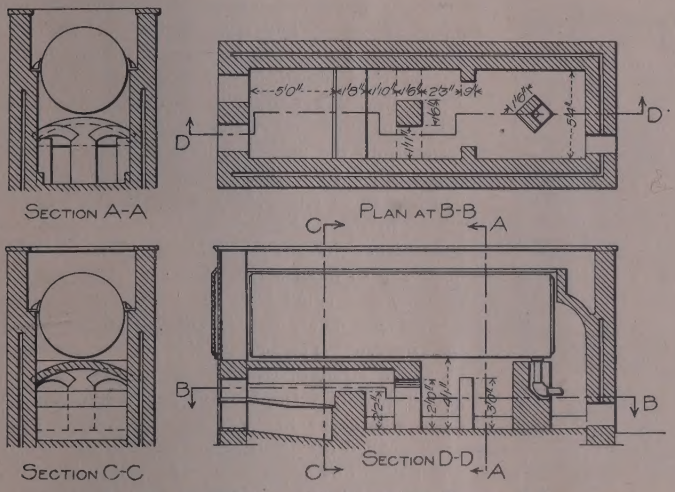
An appropriation was accordingly secured for the fitting out of the boiler equipment of a suitable school building, for the purpose of testing the two types on duplicate boiler units in a suitable school building under actual operating conditions, and of conducting comparative evaporative and smoke tests upon them. The Herman Felsenthal School Building, at the corner of 41st St. and Calumet Ave., was selected as most suitable building, having two 60-in. x 18-ft. shell return tubular boilers, which were set with the Waters standard setting. The furnace of one of these units was so altered as to conform in all details with the design suggested by the Department of Smoke Inspection, as illustrated in the accompanying diagram, while the other was left unchanged. Both of the boilers have heating surfaces of 1,200 sq. ft. and grate areas of 27 sq. ft., giving a ratio of grate area to heating surface of 1 to 44.4, no deduction being made for the heating surface cut off by the fire-brick arch. In order that the trial should be conducted by disinterested parties, Messrs. Collins & Stevens, consulting mechanical engineers of Chicago, were retained to conduct the tests, and the trial runs were arranged for on consecutive days, the first being carried out on the setting with fire-brick enclosed furnace and the second on the boiler with the Waters setting; while run on different days, both tests were conducted under nearly identical conditions as to outside temperatures, and all operating conditions were kept as nearly similar as possible on both days. The coal used was of the same quality in either test, and the firing was in both cases conducted by the regular firemen of the plant. The tubes of both boilers were cleaned, and the boilers were blown down before the tests were started, and the blow-off, all cross connections in the piping and other connections that could be dispensed with were either broken or blank-flanged, in order to prevent unmeasured leakage. All water and coal used was weighed, and readings of pressures, temperatures and other data necessary were taken for the greater part at half-hour intervals, the tests being in either case carried out for 8-hr. periods. The fuel used was a grade of bituminous known as Miami coal, which costs $2 per ton of 2,000 lb. and contains, as shown by analyses, from 32.18 to 33.20 per cent. of volatile matter, the other constituents being as follows: Fixed carbon, from 44.02 to 47.92 per cent.; ash, from 10.40 to 14.60 per cent., and moisture, from 8.33 to 12.15 per cent. The calorific value was shown to be from 10,837 to 11,120 B.t.u. per pound, as fired, or from 13,736 to 14,205 B.t.u. per pound of combustible. A summary of the results of the first series of comparative tests are presented in Table 1.

TABLE 1.—SUMMARY OF BOILER TESTS AT THE FELSENTHAL SCHOOL, CHICAGO.

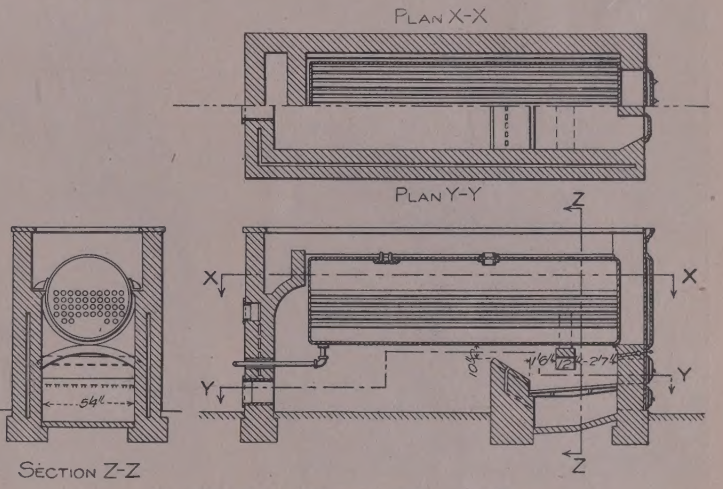
FIRST SERIES.

	Date. Jan. 2.	Date. Jan. 3.
	Boiler Setting. Firebrick Enclosed Furnace.	Boiler Setting. Waters Setting.
Rated hp. of boiler	100	100
Hp. developed	117.8	104.1
Steam pressure, average	30.18	37.4
Temperature of outside air, average	32.3°	34.6°
Coal fired per hour, lb., average	625	481
Dry coal per sq. ft. grate surface, lb.	20.3	16.1
Temperature of gases in breeching	386.2°	373°
Draft in breeching, ins. of water	0.503	0.47
Percentage of CO in flue gases	10.1	9.06
Water fed per hour, lb.	3378	2978
Temperature of feed water	35.5°	36°
Equivalent water from and at 212° F., lb.	4064	3592
Equivalent water, per lb. coal as fired.	6.503	7.463
Equivalent water, per lb. of combustible	8.965	9.918
Efficiency of boiler, including grate, per cent.	57.75	64.82
Cost of fuel to evap. 1000 lb. water	$0.185	$0.1616
Cost of fuel to evap. 1000 lb. feed water from and at 212° F.	$0.1538	$0.134

The results secured, as regards smoke production, were very satisfactory, the smoke from the stack being characterized by the representatives of the City Smoke Department who were present as "slight" in both tests. During the first hour of both tests the smoke emitted was considerable for a short interval immediately after firing, but in neither case was very black smoke given off for more than a few seconds. During the remainder of the tests the Waters setting, it was observed, was operated with very little smoke at any time, the condition of the stack being somewhat better during this portion of the run than the fire-brick enclosed furnace. The latter furnace also required cleaning of the fires three times, against one cleaning for the Waters setting, which cleanings were the cause of considerable loss of efficiency and also production of smoke. They also caused serious reductions in the steam pressure.



Details of Setting with Firebrick Enclosed Furnace.



Details of the Waters' Boiler Setting.

The conclusions reached from this series of tests were that as to efficiency and economy of fuel the Waters standard setting of the Board of Education was superior to and, as regards smoke prevention, fully equal to the furnace advocated by the Smoke Inspector. But the Smoke Inspector contended that too much care had been exercised in the firing to give results representative of ordinary operating conditions, and requested that a second series of tests be made. These were arranged for and carried out in the second week following, using the same settings and under other conditions as nearly similar as was possible. The same precautions were taken prior to conducting the tests, and the records were taken in the same way throughout. Table 2 presents a summary of the results of the second series.

TABLE 1.—SUMMARY OF BOILER TESTS AT THE FELSENTHAL SCHOOL, CHICAGO.

SECOND SERIES.

	Date. Jan. 11.	Date. Jan. 12.
	Boiler Setting. Firebrick Enclosed Furnace.	Boiler Setting. Waters Setting.
Rated hp. of boiler	100	100
Hp. developed	96.1	93.9
Steam pressure, average	45.6	46.15
Temperature of outside air, average	37.1°	32.8°
Coal fired per hour, lb., average	550	478
Dry coal per sq. ft. grate surface, lb.	18.63	16.11
Temperature of gases in breeching	508°	443°
Draft in breeching, ins. of water	0.41	0.30
Percentage of CO in flue gases	7.2	7.6
Water fed per hour, lb.	2742	2678
Temperature of feed water	35.5°	35.5°
Equivalent water from and at 212° F., lb.	3315	3239
Equivalent water, per lb., coal as fired.	6.028	6.819
Equivalent water, per lb. of combustible	7.771	8.689
Efficiency of boiler, including grate, per cent.	53.72	60.45
Cost of fuel to evap. 1000 lb. water	$0.2006	$0.1773
Cost of fuel to evap. 1000 lb. feed water from and at 212° F.	$0.1658	$0.1467

The results secured in the second series were very similar to those from the first series, the conditions differing only in minor details, and the Waters setting to a similar degree proved superior to the firebrick enclosed furnace. As to smoke emission, records were in these tests kept of the condition of the stack by representatives of the Department of Smoke Inspection, based on regular observations, which showed an average of 3.41 per cent. of smoke for the firebrick enclosed furnace and of 4.16 per cent. for the Waters setting, or, in other words, very little smoke from either setting. Like the first series, however, with both settings smoke was produced during the first hour. In this series a record was kept of the fuel, including kindling wood, required to raise steam in the boiler, with a result that 175 lb. more coal was used in the firebrick enclosed furnace, the wood used being the same in both cases, about 100 lb. The extra heat is believed to have been absorbed by the brick work of the firebrick arch, to be given off gradually after the plant is shut down.

As a result of the tests the following calculations were made, based on the results of the second test, in which the conditions were more nearly those which would be met with in actual practice. The first test was started with both boilers and setting cold, and this gave the Waters setting a large advantage, which may be noted by the increased amount of coal required to raise steam, with firebrick enclosed furnace, of 400 lb. In the second test the firebrick enclosed furnace had the advantage at the start, as the water in the boiler was 194° Fahr., as against 140° Fahr. in the Waters setting; yet, even with 54° Fahr. to its credit, the firebrick furnace took considerable more coal to raise steam (175 lb.).

Assuming that of the 150 heating days of the school year 90 days would require the use of two boilers and 60 days the use of one boiler, there would be a total of 240 boiler days. As 475 lb. of coal were required to raise steam on the boiler with the Waters setting, 114,000 (475 x 240) is the total coal used per year in getting up steam in the morning. There were approximately 300 tons, or 600,000 lb. of coal used last year, so that this amount may be taken as an average of coal required each year. Then 600,000 lb. less 114,000 lb., or 486,000 lb., would be left for maintaining steam during the day. The evaporation from and at 212° Fahr. for the Waters setting was 6,819 lb. of water. Then 486,000 lb. × 6,819 equals 3,314,034 lb. of water which would be evaporated per year by the Waters setting.

To evaporate the above amount of water with the firebrick enclosed furnace, which evaporated 6,028 lb. of water per lb. of coal, 549,773 lb. of coal would have to be burned per year. The difference in cost of fuel for one year may then be summed up as follows:

	Firebrick Furnace.	Waters Setting.
Cost of coal to raise steam at $2.40 per ton	$187.20	$136.80
Cost of coal required to supply steam during year.	659.73	583.20
	$846.93	$720.00
	720.00	
Difference in cost of fuel	$126.93	
Or for one boiler	$63.46	

ELECTRICALLY OPERATED CENTRIFUGAL PUMPS are employed at the Goldstein well plant of the water-works of Frankfort, Germany. There are three pumps, each driven by a 120-hp. alternating-current motor. The lift is 223 ft. Each pump has a suction pipe on each side, provided with an air chamber and controlled by gates. There are 27 wells, each nearly 46 ft. deep and about 217 ft. apart on centers. In sinking these wells the earth was excavated to a depth of about 5 ft. above the level of the underground water, and below this a hole 3¼ ft. in diameter was sunk, into which a copper screening tube of a diameter of about 2 ft. was inserted. No protecting cover of gauze was used, but the space between the tube and the sides of the hole was filled with selected gravel. For the removal of the air carried with the water into the suction pipe a small air pump driven by an electric motor is used.

The Fire at the Dayton Motor Car Works.

By J. B. Gilbert.

A serious fire at the plant of the Dayton Motor Car Co., Dayton, O., briefly mentioned in The Engineering Record of March 14, has furnished a very interesting demonstration of the efficiency of reinforced concrete as a fireproof building material. No more convincing exhibit could possibly have been made than that set forth in the following notes.

The main portion of the factory consists of a mill-construction building of five stories and basement, adjoined by a reinforced concrete building, U-shaped in plan and six stories and basement in height; in fact, the two buildings were practically made a continuous unit, as the walls of the brick building served as the boundary of the concrete building on the open side of the U, communication being afforded between the two buildings by doors on each floor. It will be necessary to bear this in mind to understand properly the description of the events to follow.

The concrete building was erected during the summer of 1907 by the Keppele Hall Co., consulting engineers and contractors, of Dayton. The system of reinforcement employed was a combination of the Kahn trussed bar, the cup bar and the Kahn expanded metal, all products of the Trussed Concrete Steel Co., of Detroit. The only feature of the building which was not absolutely fireproof was the window frames and sash, which were of the ordinary wood construction.

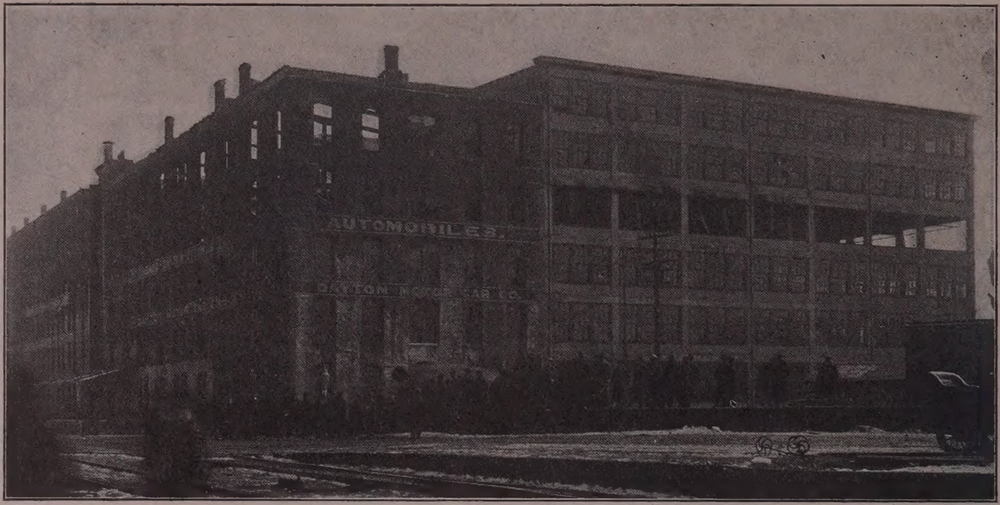
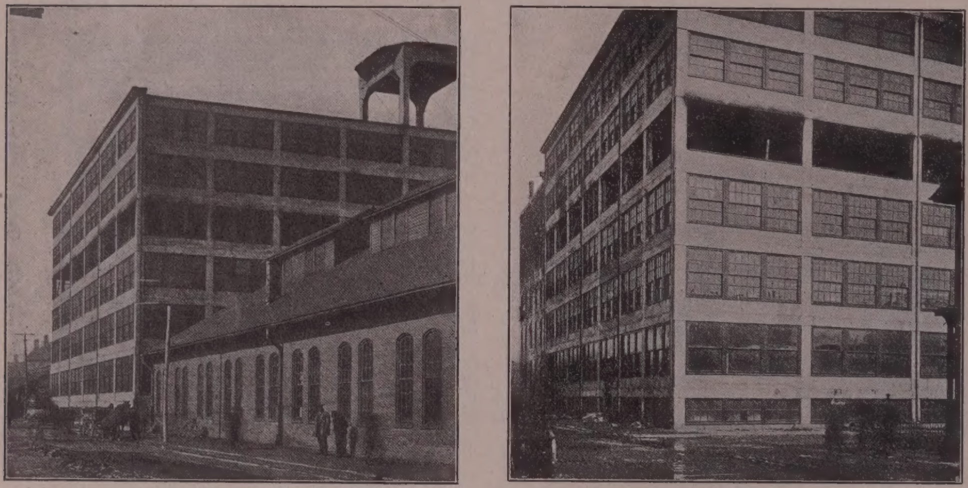


Fig. 1. General View of the Burned Dayton Motor Car Buildings.



Figs. 2 and 3. Views of Two Corners of the Concrete Building.

At 2 a. m. Friday, Feb. 21, fire broke out from some unknown cause on the fourth floor of the new building, which floor contained the upholstery department of the factory. On this floor were large quantities of excelsior, curled hair, dry wood, composing bodies of automobiles, and other inflammable materials in large quantities. The fire soon spread over the entire fourth floor of the concrete building, and, not being impeded in its progress by fire doors between the new and old building, the flames were soon communicated to the old building, where the greatest damage was done. When the fire department arrived on the scene it was apparent at a glance that the greatest destruction would be in the old building, and the chief of the department directed his men to confine their attention to it and allow the reinforced concrete building to take care of itself. Results fully justified the confidence which he placed in this type of construction. The fire burned itself out on the fourth floor of the new building, and, in burning out the window frames and sash, the flames licked outward and upward, and in some few instances burned the sash out of the windows above on the fifth floor, but not enough to cause any serious damage.

It was not long before the fire was confined to the old building, and inside of three hours the fourth and fifth floors and roof had fallen down onto the third floor, a charred mass of ruins. The fire was stopped at this point, but the building is a wreck. The walls remain standing and may be fit for a new interior, but even they bear a pathetic and eloquent testimony to the inefficiency of that type of construction under stress of fire.

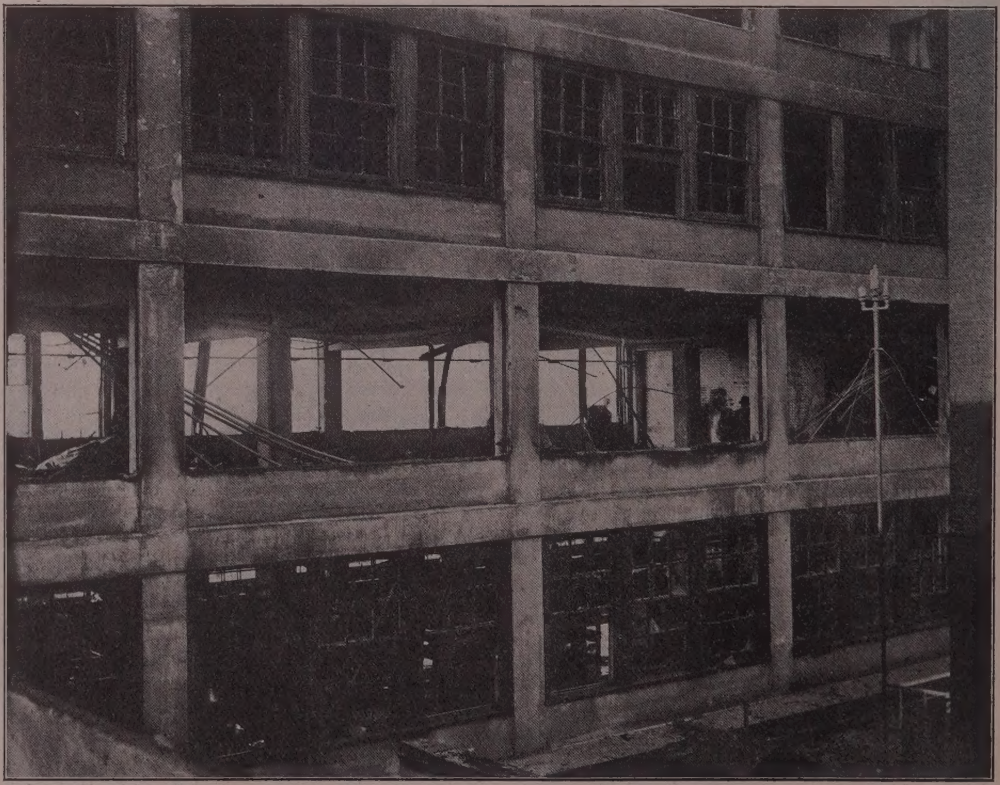


Fig. 6. View in Interior Court of Dayton Motor Car Works.

The heat under the ceiling of the fourth floor of the new building was so intense that the iron pipes of the sprinkler system were bent completely out of shape, in some instances having sagged clear down to the floor. It should be stated that the automatic sprinklers were just being installed, no water having as yet been turned into the pipes. Thus the burnt area was unprotected from that source. Throughout the building wood plugs about 2 x 3 in. had been inserted in the under side of the floor panels for convenience in attaching electrical wires. The heat was so intense that these, although exposed on only one small surface, were in many cases burned completely out, leaving an empty hole in the concrete. Yet, despite this intense prolonged heat, the strength of the building was not impaired in any respect or at any point. At one place where the fire was most intense the concrete spalled off from the corners of two beams for a length of about 4 ft. and a width of about 2 in. No cracks are discoverable either in the floor panels or in any beams and girders.

One point was brought out by this fire that has a very practical bearing on the treatment of finished cement floors on a reinforced concrete slab. The concrete entering into the construction of this building was a 1:2:4 mixture, while the finished coat of 1 in. in thickness was the usual mixture of one part cement to two parts sand. The finish coat was applied as soon as possible after the main slab had been poured, but, very naturally, after it had taken its initial set. The two mixtures, differing as they did and being poured at slightly different times, inevitably furnished different degrees of shrinkage in the process of setting and drying out. The consequence was that the union between the two was imperfect. When subjected to a test by this fire the unequal expansion of the main slab, increased by the expansion of the steel imbedded in it and of the finish coating, gave rise to irregular cracks through the finish coat. Where the heat was greatest the finish coat separated from the slab and bulged up in great molds. All this coat throughout the burned area has had to be replaced.

Another point of interest more especially to builders in the territory adjoining Dayton is the effect of this fire on the aggregates used in pouring this building. The chief ingredient in point of bulk was washed river gravel, 1 in. in diameter and smaller. Its splendid resistance to this fire demonstrates beyond the shadow of doubt its fitness for this use. Had this aggregate contained any considerable amount of free lime in its composition the fire would certainly have proved disastrous.

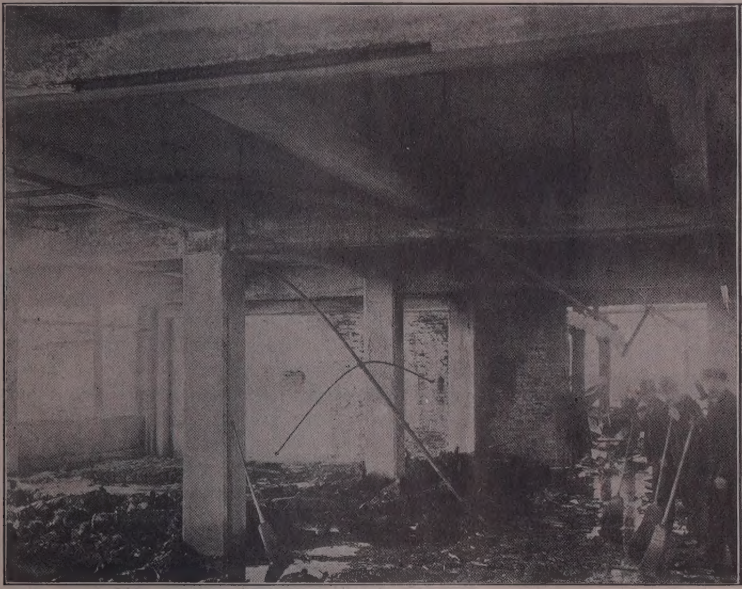


Fig. 4. Where Fire was Hottest.

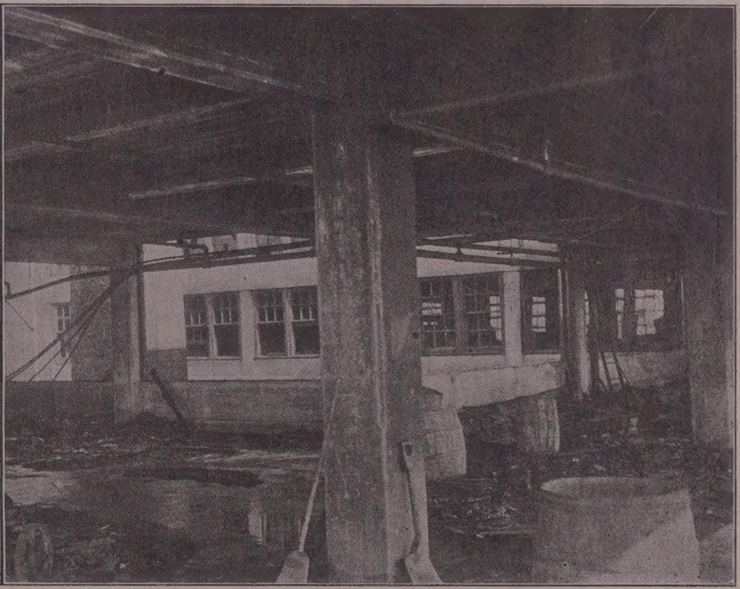


Fig. 5. Broken Floor Finish.

It is interesting from the manufacturers' standpoint to know that within two days after the fire the machinery was running in this building and operations were resumed. The two days mentioned were consumed in clearing away the débris incident to such a fire. The fourth floor, where the most damage was done, was piled to its full capacity with salvage from the stock stored in the destroyed brick building, thus proving its safe condition.

It is safe to say that if the fire doors had been in place between the new and old buildings, so as to confine the fire to the floor on which it originated, the damage would have been trifling, even though the sprinkler system was not in operation. The fire department could then have devoted some attention to the concrete building and checked the flames before they had burned themselves out.

In the accompanying illustrations, Fig. 1 shows a view of the burned buildings looking toward the brick structure. From this it is evident what happened. The two top floors of the brick building are entirely wiped out, and the damage to the concrete building is confined to the window frames and sash. Fig. 2 shows a view of the concrete building on the opposite corner, from which it is apparent that the damage on this side was also confined to the fourth floor window frames and sash. Fig. 3 shows the south side and west side of the building, on which the damage was about the same as the other views show.

Fig. 4 shows an interior view at the point where the fire burned hottest. It shows the contents of the floor reduced to ashes, and on the ceiling shows the only two places where the concrete spalled off on the corners of a beam and girder. This spalling off occurred after the fire was out, during the process of cooling off and consequent contraction. The steel was not exposed during the fire. A rough surface is noticeable on the second column shown in this view. This was roughened with a hammer after the fire to determine what condition it was in. Fig. 5 is another interior view, showing broken condition of the cement finish coat and distorted sprinkler pipes and heating pipes. Fig. 6 shows a view of the interior court, where it may be seen how the fire damaged the sash in some cases on the floors above. It will be noticed also that the sash on the third floor are damaged. This came about by burning parts of the fourth floor windows falling down on the roof of an adjoining building and communicating the fire to them.

In order to ascertain whether the structure had been damaged to any extent or had been weakened by the fire, it was decided to make a load test on the floor above that on which the fire originated. Before making this test a careful examination of the concrete on the under side of the beams and girders was made, and all of the concrete which had become vitiated by the intense heat was knocked off with a hammer. In some cases this exposed the steel reinforcement. The beams and girders which were most seriously affected in this way were selected as the ones on which the test should be made. The building was designed for a live load of 120 lb. per square foot, and the girder over which the test was made had a span of 22 ft. Equal areas on both sides of this girder were loaded so as to give a uniformly distributed load. The area covered was 352 sq. ft., on which were piled 77,250 lb. of pig iron, fly wheels and any available heavy material which could be obtained at the plant. This gave a uniformly distributed load of about 218 lb. to the square foot, and under this load the girder in question showed a deflection of only 3/16 in. at the center of the span. Had more material been available the test would have been carried further as a matter of interest in determining how much of a load could be carried before an alarming deflection was reached in the girder. The owners, however, on observing the amount of material which had been piled on the floor, were so thoroughly convinced of the stability of the structure and of the fact that in practice it would be impossible for them ever to load their building to such an extent, that they did not feel it at all necessary to go any further by obtaining materials elsewhere for the heavier loading.

One fact of great importance was very thoroughly demonstrated, namely, that the utmost care should be used in so placing the steel that it will remain in position during the pouring of the concrete. In this building the greatest care had been exercised to secure this condition, but in spite of all precautions it was found that in some few cases the steel reinforcement was within ½ in. of the surface. The fact that the steel remained uninjured even under this condition is a very high recommendation as to the fire-resisting qualities of concrete, but a warning to use the utmost care in seeing that the steel is not misplaced during the process of pouring the concrete. In the majority of cases in this building the steel was imbedded at the proper depth.

Since receiving the above article the following letter from Mr. Frank B. Ramby, chief of the Dayton fire department, has been obtained for publication from the Trussed Concrete Steel Co., to which it was sent:

"In reply to your favor of the 10th, in which you refer to the recent fire in the new reinforced concrete building at the Dayton Motor Car Co.'s plant, I would state that, this being the first fire we have had in a building of concrete construction, I am highly pleased with the results of this fire. When I arrived on the scene the fire had extended over the entire fourth floor. The entire contents of this floor were destroyed. The building, however, escaped with slight damage.

"Through the absence of fire doors and the inability of our department being able to withstand the intense heat and smoke, the fire communicated itself through an opening into the adjoining five-story brick building and was confined to the two upper floors. The biggest fight was carried on here, and it was in this building that the greatest loss was sustained. The lower floors being occupied by the offices and warerooms of the company, suffered greatly from water.

"The new building, being of concrete construction, aided us greatly in preventing the fire from wiping out the entire plant, as we were able to concentrate practically our entire force on the old building, it requiring but a small force to subdue the fire in the concrete building.

"In my opinion, there are a few points that the results of this fire have proven, namely:

"First, that the reinforcing steel should be covered with at least 2 in. of concrete, because the fire, having penetrated the lower inch of concrete, would have injured the strength of the structure had it not been for the rigidly attached diagonals.

"Second, that the finished cement surface should be put on when the floor is being laid, thereby forming a solid mass, because the finished surface was destroyed wherever the heat was intense, the slab underneath being uninjured.

"Third, as we were hampered greatly in handling our ladders and several of our firemen had a very narrow escape from being injured or possibly killed by falling sashweights, and we were compelled to force into the building all window frames that had not already fallen before we could use our ladders to advantage, I would suggest that in the construction of a building an iron pipe be imbedded in the concrete for the weights to fall into, in case the window frames are destroyed by fire. If this plan were adopted in the construction of a building it would enable the firemen to reach the fire without endangering their lives and would assist greatly in reducing the fire loss."

Book Notes.

The history of the high-speed steam engine should be of interest to all who take pride in the notable work done by Americans in developing this type of prime mover. Among those who did most to design and introduce the high-speed engine, Mr. Charles T. Porter holds a foremost position, and accordingly his "Engineering Reminiscences" is not only an autobiography but also a record of the development of an engineering specialty of which the author speaks with the authority of active participation in the work he describes. In the modest preface to the volume, he states that he refused at first to write a story in which he must be the central figure, and only consented at last because it was desirable for engineers to have a record of the origin and early development of the type of engine he made a success. It is a pity that more engineers who occupy a like commanding position in the development of important specialties will not follow Mr. Porter's example, particularly his frankness regarding the numerous failures that preceded his successes. In fact, the book is a model of its kind, written with very many humorous comments and full of the charm of scholarship tempered by the broad views that come only with intimate acquaintance with men of all degrees in many countries. His account of his first association with engineering work by redesigning a stone-dressing machine is a charming story of the way in which the natural talents of a mechanical genius dragged him away from an uncongenial legal practice. This machine required a governor on the engine driving it, and accordingly the first Porter governor was constructed, a device of the greatest importance. A company was formed for making it and the sales became satisfactory very soon. While Mr. Porter was visiting an engine room to see about installing one of these governors, he met John F. Allen, the engineer of the shop, who showed him a link motion he had thought out but never built. The two men quickly came to an agreement. Mr. Porter bent his energies to the design of a high-speed engine, in which work Mr. Charles B. Richards was of much assistance. A small experimental engine ran successfully and a larger one was at once designed. The parts of the engine were made in this country and shipped to England without being assembled, in order that the engine might be shown at the London Exposition of 1862. It was not ready until a week after the Exposition opened, but it ran smoothly from the moment steam was turned on. It made 150 r.p.m. and was the first high-speed engine publicly exhibited. It ran non-condensing, however, which prevented any value being attached to it by Englishmen, who used only condensing engines at that time, although they showed much interest in it as a curiosity. By arranging to run it condensing this prejudice was overcome and the sale of the Porter-Allen engine was begun in England on that basis. The rest of the story told by Mr. Porter is too long to summarize; it is told in a way that holds attention and nobody can read it without feeling grateful to its author for his willingness to sacrifice his time to write it out for the encouragement of those who are now overcoming obstacles in the way of the success of their inventions. (New York: John Wiley & Sons, $3.)

Some months ago mention was made in this journal of the appearance of the first volume of the "Illustrated Technical Dictionary," a work undertaken by a Munich publisher, R. Oldenbourg, who has engaged a large staff particularly for the editorial work, which is under the general direction of Messrs. K. Deinhardt and A. Schlomann. Leading publishing houses in the United States, England, France, Russia, Italy and Spain are co-operating with the Oldenbourg house in the work, and while the first edition of a dictionary in English, German, French, Russian, Italian and Spanish must inevitably contain errors, it is believed that this dictionary has fewer than others. The second volume, on electrical engineering, has been compiled under the direction of Mr. Chas. Kinzbrunner, with the assistance of several hundred collaborators. The book has 2,100 pages and its contents are subdivided as follows: 1, cells and batteries; 2, boilers and prime movers; 3, electrical machinery; 4, switch apparatus; 5, measuring instruments; 6, electric supply stations; 7, mains; 8, wiring; 9, lighting; 10, various applications of electricity; 11, telegraphy; 12, telephony; 13, electro-chemistry; 14, electro-medical apparatus; 15, electrical units; 16, appendix. Electric traction will be considered in a subsequent volume on railway engineering. The arrangement of this work is unique, and best indicated by an example. Suppose an engineer reading a French paper comes across the word "tamponnoir," and wishes to know what it means. He turns to the alphabetical index, which refers him to the first definition on page 399. A reference to this page gives a picture of the tool, a stone drill, and its name in six languages. The definitions include a great range of subjects, for electrical engineering is so comparatively new and so many things of a mechanical nature arise in connection with the design and manufacture of electrical apparatus, that it is difficult to know just where to draw the line separating words and phrases suitable for this volume and for some others of the ten that will make up the complete work. Now that the "Technolexicon" has been abandoned by the Society of German Engineers, this dictionary is by all odds the most important undertaking of its kind, and for this reason the following extract from the preface is of interest: "One of the chief difficulties that had to be overcome lay in the fact that there are a large number of words which, though linguistically alike, are technically entirely different; in such cases these words are illustrated wherever possible. A number of perfectly identical words will be found in different places, on account of their importance in connection with other words. As a rule, however, such expressions are given in those chapters only in which they are most important for the clear conception of other words and phrases. As far as we know there is no other dictionary in which the whole subject has been dealt with as fully as in this. That this could be achieved at all is due solely to the method adopted in compiling the dictionary, more especially the introduction of illustrations and the arrangement of the whole work into several volumes, each dealing with one branch of engineering only." (New York: McGraw Publishing Company, $7.)

Letters to the Editor.

Resistance to Fire of Concrete Blocks.

Sir: I have read with much interest your article in the issue of 14th inst. entitled "Specifications for Concrete Hollow Blocks" and beg to say that the increasing use of such blocks in building construction is something that not only interests me and all other fire insurance men, but also causes us more or less solicitude. This solicitude is due to the fact that, all over the country, Tom, Dick and Harry seem to have the idea that, given any old sandbank and a block machine, an everlasting fortune can be made in short order. They know little, and care less, about the chemical make-up of the sand they propose to use, and when it comes to proportions of the "mix," why, almost zero per cent. of cement would suit them to a dot if, in that way, they could turn out a block that they could sell to a gullible public.

As a result of this uncertainty regarding composition and manufacture, insurance companies generally, up to the present time, class as no better than frame all buildings of hollow concrete block construction. I am glad that the National Association of Cement Users have started the ball rolling by adopting standard rules and regulations governing concrete hollow block, and hope that they will soon take steps to co-operate (if they have not already done so) with the National Fire Protection Association, to the end that there shall not only be a standard block on the market, but also that provisions shall be made whereby the use of such a block can be insisted on, just as is the case with electrical fittings, fire hose, wire glass and many other appliances that have been tested and approved by the Underwriters Laboratories of the National Fire Protection Association, located at Chicago. Yours truly,

Columbus, March 16. Fred. W. Ransom.

The Capitol Subways at Washington.

Sir: In reading the interesting article in your last issue by W. J. Knight on the Capitol Subways, I recalled a recent discovery I made in the House of Representatives Subway. At the curve shown in the general plan of the House office building subway, at the House end, close by the steps, I found that very low sounds, almost whispers, could be heard with great distinctness about 100 to 150 ft. further on, near and opposite to the fan chamber.

The drawings show that this curve is an arc of a circle instead of being elliptical; nevertheless, it may be possible to locate points which would act virtually as foci, in which event the spot would be a very remarkable one as a whispering gallery. Furthermore, if these walls should be smooth finished with a hard plaster, the reflection, and consequently the echo, would be almost perfect. Respectfully,

New York, March 21. Chas F. McKenna.

Fireproof Wood and Fabrics will be given a competitive trial shortly by the Executive Committee of the Turin International Exposition.